THE ANATOMY OF SURGERY.

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BY

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TO

JOHNSON SYMINGTON, M.D.,

F.R.S.E., F.R.C.S.E.,

Lecturer on Anatomy, School of Medicine, Edinburgh,

IN RECOGNITION OF HIS GREAT SKILL AS A TEACHER

AND AS AN EXPRESSION OF SINCERE REGARD,

This Book is respectfully Dedicated

BY

AN OLD PUPIL.

PREFACE.

In preparing the following pages for the press, I have endeavoured to write, as a Student, to Students; in this way I hope I have been enabled more thoroughly to meet the wants of Students preparing for the various Final Examinations throughout the Kingdom. The present book is intended to replace a small book I published some years ago, but is to be regarded as essentially different in all respects. It is intended to be sufficient for the various Higher Examinations, as well as for those of less severity, and especially is it intended for those Examinations that require actual operations on the dead body as part of the Final or Pass Examination. I have used every effort to make it as complete as possible, but it has been very hurriedly put together, and it is possible that some points may have been omitted; for these, and all errors in the book, I would humbly crave the reader's pardon. The *Lancet*, in its kind and favourable review of my

first book, drew attention to some points wherein it was deficient—chiefly in relation to 'Surface Anatomy' I trust the present book is less deficient in that respect, but there are some things that cannot be learned except beside the living, or dead, body. I have certainly pointed out the special relations of the various important bony points that can be felt, or seen, on the surface of the body, but to learn the Surface Anatomy properly, the Student *must* have the actual body beside him to see and feel for himself.

My thanks are specially due to PROFESSOR CHIENE who, with characteristic kindness, has permitted me to make use of any part of his lectures bearing on the subjects discussed in this book. In many parts of the book he will discover the reflection of his own teaching, for it is to him that I am indebted for what knowledge of the Principles of Surgery I possess, and I am glad to take this opportunity of acknowledging that indebtedness.

The name of the book requires a few words, not by way of apology, but by way of explanation. It has at least the advantage, so far as I am aware, of being original. The name, *Surgical Anatomy*, is a bad one. It seems to indicate that the ordinary dissecting-room Anatomy, and the Anatomy required in Surgery, are two different things; now, this is a great mistake, for all

Anatomy is Surgical. In talking over the matter with my friend, Mr W. F. Grier, and explaining to him my views on this question, after several unsuccessful attempts to please me, he at last struck on the name placed at the beginning of this book. I looked at it from all points of view, and gradually came to the conclusion, that, on the whole, it was perhaps the best title we could find. We have already such books as *The Anatomy of Melancholy* and *The Anatomy of Drunkenness*, why not have the *Anatomy of Surgery* as well? At first I was rather inclined to name it *The Surgery of the Dissecting-room*, but I was afraid that the latter part of this name might frighten certain timid Students, and thus spoil the sale of the book, as well as being a great loss to the Students in question.

The greater number of the engravings are original—most of them being prepared from rough sketches by the Author; but for their elaboration and execution I must express my thanks to Mr D. L. Turnbull, who has engraved all the plates, with but five exceptions. I must also express my thanks to Messrs Longmans, Green, & Co. for permission to insert Nos. 41 and 42, and to Professor Cunningham for permission to insert Nos. 59 and 60, as well as to his Publishers (Messrs Maclachlan & Stewart) for the ready and courteous manner in which they furnished the necessary electro-

types. If at times, in the drawings, I have sacrificed strict scientific accuracy, for the sake of impressing special points on the Student's mind, I must be excused, for what is the use of engravings unless they *impress* the idea they are intended to convey, and teach some practically useful fact.

I have tried, as far as possible, to 'give honour to whom honour is due,' and many familiar names will be found throughout the body of the work, associated with special facts. For the rest I need only, in a general way, acknowledge my indebtedness to the standard works of Anatomy and Surgery of the day, without further specifying the works in question.

J. M'L.

EDINBURGH, *May 1887.*

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LIST OF ENGRAVINGS.

ERRATA.

Page 46, second line from bottom, *for* omo-hyoid *read* 'sterno-thyroid.'
" 82, fourteenth line from bottom, *for* vessels *read* 'vessel.'
" 88, ninth line from top, *for* anastomoses *read* 'anastomosis,'
" 114, top line, and elsewhere, *for* cælic *read* 'cœliac.'
" 118, fifteenth line from top, *for* external *read* 'internal.'
" 166, fourth line from top, and elsewhere, *for* Teal *read* 'Teale.'
" 202, seventh line from bottom *for* Faps *read* 'Flaps.'
" 206, third line from bottom, *for* surgical *read* 'anatomical.'
" 213, seventh line from bottom, *for* or *read* 'of.'
" 218, eighth line from bottom, *for* Tarto *read* 'Tarso.'
" 293, twelfth line from top, *for* ankylosis *read* 'ankyloses.'
" 307, in description of engraving, transpose 6 and 7.
" 350, thirteenth line from top, *for* internal *read* 'external.'
" 365, fourth line from bottom, *for* fracture *read* 'fractures.'
" 365, third line from bottom, *for* necks *read* 'neck.'
" 400, eleventh line from bottom, *for* o umerus *read* 'of Humerus.'
" 417, sixth line from bottom, *for* any *read* 'no.'
" 426, in description of figure 32, *for* rhe *read* 'the.'
" 524, fifth line from top, *after* look *place* 'into.'
" 561, top line, *for* Gasserian *read* 'Geniculate.'
" 581, in description of figure 52, transpose 12 and 13.
" 600, sixteenth line from bottom, *for* heel *read* 'anterior part of foot.'
" 608, twelfth line from top, *for* propogation *read* 'propagation.'
" 649, fifteenth line from top, *for* of *read* 'by.'
" 669, ninth line from bottom, *for* opened *read* 'open.'
" 691, thirteenth line from top, *for* riangular *read* 'triangular.'

NOTE.—*I would take this opportunity of thanking* J. T. TIBBLES, Esq., *Melton-Mowbray, who kindly sent me a very complete list of "errata."*

J. M'L.

THE ANATOMY OF SURGERY.

CHAPTER I.

ANEURISM.

In introducing the subject of ligature of arteries, I propose to say a few words concerning aneurism and its treatment. An *Aneurism* may be defined as a tumour containing blood, either fluid or coagulated, communicating with the cavity of an artery. Mr Erichsen thus classifies the different forms:—

I. Fusiform—True.

II. Sacculated.

(*a*) True.

(*b*) False.

(1) *Circumscribed.*

(2) *Diffused.*

III. Dissecting.

Cirsoid aneurism, and arterio-venous aneurism are not included in this classification. Formerly a *true* aneurism meant one whose wall was formed by all the three coats of the vessel; as a rule, it now means an aneurism whose wall is formed by one or more of the arterial coats.

I. **Fusiform** or **Tubular** Aneurism consists of an equal expansion of *all* the coats of the vessel through-

out its entire circumference; this form is most frequently met with in the arch of the aorta.

II. **Sacculated** Aneurism means a tumour springing from the *side* of an artery, or from a tubular aneurism, with the interior of which it communicates by a narrow opening called the mouth of the sac. (*a*) In *true sacculated*, the sac wall is formed by all the coats of the vessel; (*b*) in *false sacculated*, the internal or middle coat or both are deficient, and the wall of the sac therefore is formed by the outer and middle coats only, or else by the outer coat alone. To this latter condition the name of *circumscribed false* aneurism is sometimes applied: *diffused false* aneurism means that the sac of the aneurism is not formed by the coats of the artery at all, but by the tissues outside the vessel; the blood being either confined by the condensed tissues of the part into a *circumscribed* tumour or else widely *diffused* in the loose cellular tissue.

III. **Dissecting** Aneurism.—In this form the internal coat of the artery becomes eroded, or an atheromatous abscess bursts, and the blood makes its way through the ulcer or erosion and burrows between the coats of the vessel. As a result of this it may either burst through all the coats and be effused into the surrounding tissues, or, if the external coat be strong enough to resist the rupture, the blood travels along between the coats for some distance, and again opens into the cavity of the artery; or, thirdly, it may form a sac in the middle coat, which may remain for a time unaltered, but which will probably at last burst externally.

Various other methods of classification are adopted by different writers, *e.g.*, some divide aneurisms simply into—(1) **True**, where the sac wall is formed by one

or more of the coats of the vessel, this form being associated with *disease* of the artery. (2) **False**, where the tissues *outside* the vessel form the sac wall, this form being caused by a wound of the artery, or else the bursting of a true aneurism. Others again divide them into—(1) **Spontaneous** (due to disease). (2) **Traumatic** (from injury, as a wound penetrating from the surface, strain or bruise without wound, fractured bone penetrating the vessel). (3) **Arterio-venous.** (4) **Cirsoid.**

Arterio-venous Aneurism is usually caused by a wound implicating an artery and some neighbouring vein; in some rare cases it may arise from disease. Of this condition there are two forms—(1) *Aneurismal varix.*—In this form the wounded artery and vein have adhered closely, and the inflammatory exudation caused by the injury has fixed them in this position, and at each pulsation a jet of arterial blood is projected *directly* into the vein, dilating it and causing incompetence of its valves and gradually leading to a varicose condition of the neighbouring veins, both superficial and deep. The veins become tortuous, thickened, and may pulsate, but there is no formation of a real aneurism. (2) *Varicose aneurism* consists in the formation of an aneurism from the yielding of the cementing lymph, the sac of which communicates with both the artery and vein, the blood being projected from the artery *through the sac* into the vein, dilating it as in aneurismal varix. By far the most frequent cause of arterio-venous aneurism is the unskilful performance of venesection at the bend of the elbow, resulting in the simultaneous wounding of the brachial artery and the median basilic vein: it is but rarely seen now-a-days.

since this operation is not often performed, and only by surgeons. Any punctured wound, however, may cause it, *e.g.* from small shot, or a spicule of bone in comminuted fracture.

Cirsoid Aneurism and Aneurism by Anastomosis.—These conditions result from the simultaneous elongation and dilatation of arteries with thinning of their coats, especially the middle, so that, in structure, they come to resemble veins; when large vessels are affected it is called *cirsoid aneurism*, but when the smaller arteries, capillaries and veins are involved it is known as *aneurism by anastomosis*. The arteries most frequently affected are, the superficial temporal, posterior auricular and occipital.

Causes of Aneurism.—Anything that destroys the balance between the expansive force of the circulation, and the reaction of the arterial wall; or, in other words, whatever increases the blood pressure on the one hand, or reduces the resisting force of the arterial walls on the other, as thinning of their coats or diminished resiliency. It is specially APT TO OCCUR—(1) In large vessels, because atheroma (the chief predisposing cause) is a disease of the large arteries; (2) in places subjected to great strain, *e.g.* the axillary artery in sailors, probably from climbing, hanging by their arms, &c.; (3) where large arteries bend or bifurcate, because the pressure is greatest at these points, *e.g.* the innominate, bifurcation of the common carotid, and popliteal. (*a*) PREDISPOSING CAUSES.—Anything that gives rise to a *local* weakness of the vessel wall. The great predisposing cause is atheroma, but syphilis, gout, rheumatism, Bright's disease of the kidney (especially the granular contracted form) abuse of alcohol, intemper-

ance and vice of every form, are also important predisposing causes; and all the more so because many of these conditions are accompanied with hypertrophy of the left ventricle, so that not only is the vessel wall weakened, but the blood pressure is increased as well. All occupations where sudden and severe efforts are required *irregularly*, as in soldiers, sailors, and huntsmen; it is said to be most common between the ages of thirty and forty. (*b*) Exciting causes.—Wounds or blows, sudden strains, irregular vascular excitement, as from violent exercise or emotion, fits of anger, &c., in people of a certain age, say above fifty.

Symptoms of Aneurism.—The more important symptoms are—(1) the presence of a pulsating tumour near the course of some blood vessel, and which cannot be pulled away from the vessel; (2) pressure on the artery above arrests the pulsations of the tumour and causes it to subside, but when the pressure is removed it refils again, often with a thrill; pressure on the artery below will cause it to become larger and more tense; (3) the pulsation is expansile, the tumour enlarging in all directions, and not a mere upheaval; (4) lessening of the force of the pulse in the vessel beyond the aneurism; (5) pressure effects, *e.g.* pain of an intermittent character, muscular weakness, œdema from pressure on the veins; (6) Bruit, often loud and rasping. Note, that many of these signs will be absent in consolidation.

Diagnosis.—It must be distinguished from—(*a*) Tumours in the course of Large Arteries. (1) These may be pulled away from the vessel; (2) the pulsation is not expansile and uniform, but is merely a rise and fall of the whole tumour; (3) the usual

absence of a bruit; (4) an aneurism tends to become harder day by day, whereas an abscess tends to become softer; (5) all movement is stopped at once by pressure on the proximal side of the tumour, and returns *at once* as strongly as ever when the pressure is removed; in an aneurism the pulsation returns *gradually*, and does not attain its full force for a few seconds. (*b*) Pulsatile Tumours of Bone.—(1) Bruit less marked or wanting; (2) the pulsation is more sudden, less expansile, and equally forcible at all parts of the tumour; in an aneurism there is a line of more rapid and thrilling pulsation in the course of the vessel; (3) examination of the neighbouring bone: an aneurism eats through the bone, and one may feel the edges of the hole, a pulsatile tumour growing from a bone usually expands it, so that one may be able to feel a thin shell of bone covering the tumour; (4) signs of cancer elsewhere, *e.g.* in the kidney giving rise to hæmaturia, and in all probability a well marked 'cancerous cachexia.'

Progress of Aneurism.—(1) It may remain stationary: (2) increase in size: the rate of increase depends on its position and the size of the mouth of the sac. Fusiform increase slowly; but the narrower the mouth of the sac, the greater the pressure on its walls, the more rapid its growth, and the greater the tendency to burst. This increase in size gives rise to pressure symptoms—*veins* are closed causing œdema, *nerves* expanded, thinned, or irritated, *e.g.* the superior laryngeal, causing a peculiar brassy persistent cough; the inferior or recurrent laryngeal causing spasmodic closure of the glottis, necessitating the performance of tracheotomy: the trunk of the sympathetic in the neck giving rise to

eye symptoms: *muscles* stretched and wasted, *bones* eroded and absorbed: *œsophagus* or *trachea* pressed on causing a difficulty in swallowing or breathing. (3) Rupture of the sac and death from hæmorrhage, either externally or internally as into joints, pericardium and pleural cavity. (4) Spontaneous cure—(*a*) by coagulation of the blood in the sac, due to some temporary retardation of the flow, as from the growth of the aneurism causing pressure on the artery feeding it, escape of a piece of clot causing embolism beyond the aneurism, displaced clot plugging the mouth of the artery leaving the aneurism, or a clot washed down into the feeding artery from some aneurism higher up. (*b*) Suppuration and sloughing of the sac, provided the communication between the aneurism and the sac is closed up before the abscess bursts: if not it may speedily cause fatal hæmorrhage. (*c*) It is believed by some Surgeons that an aneurism may be cured spontaneously by inflammation of the sac without suppuration.

In the first form of **spontaneous cure** there is gradual deposition of laminated clot, which tends to restore the resisting force of the wall of the vessel. The outer part of the clot ('*active clot*') consists of numerous layers of fibrin, and is firmly attached to the wall of the aneurism; these layers not only strengthen the part but they tend to contract, and as they do so they cause contraction of the sac, and gradually narrow it down to the level of the lumen of the original vessel or may even close it up entirely. In order that a clot may form, the force of the circulation must be lessened, and when the clot formation is once begun it goes on till the whole sac is full, gradually becoming denser

and contracting; it thus enables the sac to resist pressure and stops its further growth. That part of the clot next the lumen of the vessel is soft, amorphous and red, like red currant jelly ('*passive clot*'). In many of the cases examined this is, in all probability, only a post-mortem clot; but there is good ground for believing that it also precedes the firm, laminated external clot, and is also formed in those cases where an aneurism is cured by pressure in a few hours. It is well to bear in mind, however, that unless great care be taken it is apt to be broken down and washed away, and then the apparently cured disease begins again. It is most difficult to induce coagulation in vessels near the heart, on account of the difficulty in obtaining a temporary retardation of the blood current; it is specially difficult in fusiform aneurism of the arch of the aorta.

CHAPTER II.

TREATMENT OF ANEURISM.

The treatment of aneurism is divided into *Medical* and *Surgical*; but in practice it is always better to combine them.

MEDICAL.

This includes—(1) **Rest in bed** in the recumbent posture, or in such a position as to impede the supply to, but to assist the return from the aneurism, at the same time paying special attention to the general health, giving a light, simple, unstimulating diet, but one nevertheless sufficient for the needs of the body, and avoiding all excitement either mental or physical. (2) **Depletion** in moderation to reduce *excessive* vascular action; it also seems to increase the relative amount of fibrin in the blood. The effect on the circulation is not lasting, but that is no objection as all that is wanted is a *temporary* lowering of the force of the circulation in order to allow the blood in the sac to *begin* to clot. This was Valsalva's plan, only he carried it to excess, and it consequently fell into disrepute. In carrying out this method the pulse must be carefully watched and depletion stopped at once, should there seem any tendency to syncope. (3) **Gradual starvation**, *especially of fluids* (Tufnell).

with the intention of reducing the total amount of blood in the body, and also the force of the heart's action. The diet is to be chiefly farinaceous, and alcohol must not be given; by some it is recommended, after coagulation has commenced, that a liberal proportion of animal food should be allowed, in order to increase the amount of fibrin in the blood. The diet recommended is something like the following:—2 oz. of bread and butter for breakfast; 2 oz. of bread and 2 oz. of meat for dinner; 2 oz. of bread and butter for supper, and a little milk-and-water (as little as possible) sipped between times. (4) **Drugs**, such as iodide of potassium to lower vascular tension; aconite and veratria to depress and weaken the heart's action. Acetate of lead has also been recommended. It should be borne in mind, however, that drugs without rest in bed in the recumbent posture, spare diet, avoidance of all excitement, &c., are probably of little use, and that if these conditions are properly carried out they are to a great extent superfluous.

SURGICAL.

I. **Ligature.**—(*a*) Method of Antyllus (the 'old operation'). In this method the artery is commanded on the proximal side of the aneurism, the sac is freely exposed and opened, the clot turned out, and then, by means of a probe as guide, the arterial orifices opening into it are found, and the artery tied both above and below the aneurism. In many cases it is a very dangerous and tedious operation to expose the sac, as it may be deeply placed and surrounded by important structures, *e.g.*, the popliteal space; further, there is a great risk of secondary hæmorrhage when the

ligatures separate, besides, very often profuse suppuration of the deep trench-like wound thus made—it may be briefly characterised as ineffective, tedious, bloody, and dangerous. In the evolution of this operation, Antyllus made three mistakes:—FIRST, and most serious, he tied the vessel at a part where the coats were diseased; hence the great mortality and risk of secondary hæmorrhage. SECOND, he seemed to think that in order to cure an aneurism it was necessary to *completely* check the blood flow to and through the aneurismal sac; whereas all that is necessary is to obtain a *temporary* decrease in the force of the blood stream. THIRD, he had erroneous views as to the value and uses of the blood clot. He thought the clot was a vicious thing and must be got rid of at all hazards, before a cure could take place; whereas it is nature's method of cure and must be imitated by any Surgeon who hopes to be successful in the treatment of aneurism by ligature, or any other method.

There are still, however, certain cases in which the 'old operation' is specially useful. It may be regarded as *the* operation for traumatic false aneurisms, and for this purpose it was revived by Syme, who adopted this method for the cure of a traumatic false aneurism in the axilla, probably the result of rupture of the axillary artery. Under these circumstances, however, the objections urged against the operation, as performed by Antyllus, entirely disappear. Here the coats of the artery are healthy, and the operation is nothing more or less than carrying out the universal principle, that where possible the wounded vessel should be tied at the bleeding point. The following cases may be regarded as suitable for this method.

(1) Traumatic false aneurism of the axilla, bend of elbow, gluteal artery, &c. (2) In gluteal aneurisms, not necessarily the result of a wound, in preference to the dangerous and difficult operation of tying the internal iliac artery. Mr SYME used both methods in gluteal aneurism, one by the 'old operation,' the other by ligature of the internal iliac, and both with success. (3) Where an aneurism has been opened accidentally. (4) Where the sac has burst, as an alternative to amputation of the limb. (5) In cases where the diagnosis is uncertain, as, for example, between an aneurism and a pulsating malignant growth: the tumour is cut into with the view of tying the artery above and below if aneurismal, and amputating if malignant. (*b*) The Operation of Anel (1710).—This operation only deserves a passing notice. It consists of a careful dissection down to the aneurism, and then tying the vessel close to the sac, on the proximal side only, but without laying it open as Antyllus did. It is open to the same objections as those urged against the method of Antyllus (when applied to spontaneous aneurism), and can hardly be looked upon as an improvement to that method:—(1) It leaves no current through the aneurism, and makes no provision for utilising the collateral circulation, and the clot formed is likely to be soft and loose. (2) A diseased part of the vessel is selected for the application of the ligature. (3) It is often difficult from the depth and complicated relations of the sac; and there is a further difficulty in securing the vessel, more especially as there is no certain guide to it, as the probe passed into the sac in the method of Antyllus. (*c*) Hunter's Method.—Fully one hundred years ago (1785) Mr HUNTER

introduced a method which revolutionized the whole question of the treatment of aneurism by ligature. It was the outcome of sound reasoning, founded upon accurate observation of the methods of his predecessors and the causes of their failures:—(1) He saw that it was necessary to select a sound part of the vessel on which to operate; he therefore tied the artery at some easily accessible point between the aneurism and the heart, but at some distance from the sac, where the coats of the vessel were healthy. (2) He believed that the clot was not an evil thing as hitherto taught, and that it should not be interfered with as it was nature's method of cure; but that its formation and growth ought to be encouraged. (3) He said that to cure an aneurism it was not necessary to check the flow through it completely, but only 'to take the force off the circulation' for a time. (4) He trusted to the collateral circulation to carry blood to the limb beyond the ligature and thus prevent gangrene; but there should be no large vessel between the ligature and the aneurism. After the application of the ligature, the cure by blood clot begins, as the force of the stream is lessened, the aim being to produce a *temporary* obstruction only, and trust to the collateral circulation in the meantime. According to Mr HOLMES the Hunterian operation is *indicated*:—(1) Whenever an active aneurism is situated upon an artery inaccessible to pressure, but which will allow a ligature to be put round it without excessive danger, and with a sufficient space between the part tied and the tumour, *e.g.*, the iliac and carotid arteries. These vessels *might* be compressed, but the patient very often cannot bear it. (2) Where the patient from some peculiarity, con-

stitutional or acquired, is intolerant of the more gradual methods of cure. (3) Where these methods have been tried and failed. (4) When an aneurism has burst into one of the internal cavities of the body, *e.g.*, a popliteal aneurism into the knee joint. (5) Sometimes when the rupture has taken place subcutaneously. In some cases compression may be tried for a short time, but if it is not successful amputation or the ligature is indicated. According to the same authority it is *contraindicated:*—(1) In aortic and innominate aneurisms as ligature here has always been fatal. Try medical treatment first, and only have recourse to ligature as a last resort, when medical treatment fails, or if the sac is about to burst or has burst. (2) Never apply to an artery so situated as to admit of compression, unless it has been tried and failed, or is contra-indicated. (3) In recent traumatic aneurisms, especially when caused by fracture, without a previous trial of the resources of nature aided by rest, position, and pressure, direct or indirect. (4) In extensive disease of the heart and arterial system; in such a case digital compression is the best and safest.

(*d*) Another method of ligature was suggested by Brasdor, although to Wardrop belongs the credit of having first performed the operation, viz., that of tying the artery on the distal side of the aneurism. It is chiefly applicable in cases of aneurisms at the root the neck, and was originally intended for aneurism at the lower part of the common carotid, or aneurisms that hold an intermediate position (as regards treatment) between the Physician and the Surgeon. It has also been used in innominate aneurisms, where a cure was attempted either by tying both its branches simul-

taneously, or by tying the right common carotid first, and then, if necessary, the subclavian some weeks or months later. It has further been tried in mixed innominate and aortic aneurisms, and in pure aortic. A distinction is sometimes drawn between the methods of Brasdor and Wardrop. According to some writers, Brasdor's operation is ligature of the main trunk beyond the aneurism, *e.g.*, the common carotid in aneurism at its lower part; whereas Wardrop's operation is ligature of one or both of the main branches, *e.g.*, the common carotid, or the subclavian, or both, in innominate aneurism.

II. **Compression.**—This may be applied, either to the aneurism directly, or to the main artery on the proximal side of the aneurism—(*a*) **Direct pressure** (*i.e.*, on the aneurism itself) is a method not often used, and is objectionable in many ways—(1) It is apt to cause sloughing and possible rupture of the sac. (2) If this method be worth retaining, and if it be used as a means of cure, the pressure to be efficient must, to a great extent, empty the sac of blood and keep it so, in the very nature of things; but if this is the case, then the chief factor in the formation of the blood clot is absent, viz., blood itself, and it is difficult to see how the cure can be effected under these circumstances. (3) It puts the cart before the horse, as it were, or reverses the order of nature; for it aims at causing contraction of the sac as a primary thing, whereas we have already seen, in discussing the spontaneous cure of aneurism by coagulation, that the contraction of the sac follows as a secondary result upon the contraction of the fibrin of the blood-clot. (*b*) **Indirect pressure** (*i.e.*, pressure on the main artery on the proximal side

of the aneurism) may be applied in various ways—(1) *Digital*, by relays of well-trained intelligent assistants, taught how to apply a proper amount of pressure, and in the proper direction. It is as a rule simple, easy, painless, and rapid, and statistics of results are much better than those of ligature. In some cases, however, it is very painful, so that the patient must be kept under the influence of an anæsthetic. (2) *Instrumental*, as CARTE's tourniquet, or P. H. WATSON's weight-compressor for the femoral artery in the groin: SKEY's or SIGNORONI's tourniquets for the brachial artery: and LISTER's for the aorta or common iliac arteries. Whatever method be employed there must be no circular compression of the limb, and the pressure ought, if possible, to be elastic. (3) *Flexion*, (HART) may sometimes succeed in curing aneurism situated at the bend of the limb, and on the superficial aspect of the artery, *e.g.*, in the popliteal space and elbow. The limb is bandaged in acute flexion, and the patient is kept in bed with restricted diet. This method may be used when the aneurism is—(*a*) in the flexure of a joint: (*b*) not of large size: (*c*) when the coverings of the sac are free from inflammation: (*d*) when the joint is not involved; (*e*) when the aneurism is on the superficial aspect of the circumference of the artery; (*f*) occasionally when other means, such as ligature or instrumental compression, fail. (4) *Esmarch's bandage* (REID). This combines the effects of direct pressure, and the total stoppage of the circulation. Supposing the aneurism is in the popliteal space, we are directed to bandage the limb from the toes up to the popliteal space pretty firmly, then pass very lightly over the sac, or leave it free altogether, as we do not

wish to empty it of blood, and then tighten again as we ascend the thigh, and finally fasten it by an elastic tube. It should be applied under anæsthesia, and kept on for one or two hours; and after removal digital compression must be kept up for some time. It is *to be used*—(1) in cases where we hope to cure the aneurism at one sitting, *i.e.*, in small and recent aneurisms. (2) Where compression and flexion have failed. It is *not to be used* where—(1) there is any danger of the sac bursting; (2) where the aneurism is large and rapidly increasing; (3) where there is serious venous obstruction; (4) where the aneurism is inflamed. The *dangers* of this method are—(1) Rupture of the sac; (2) gangrene of the limb; (3) increase of pressure thrown upon other arteries and on the heart, especially dangerous in some forms of heart disease as, for example, fatty degeneration.

III. **Manipulation.**—The sac is manipulated so as to break up the fibrinous clot, and part of the broken up clot is displaced, with the intention of plugging the artery on the distal side of the aneurism (Sir W. Fergusson). In the case of aneurism of the vessels at the root of the neck it is a very dangerous and difficult proceeding and has been followed by hemiplegia, from plugging of the middle cerebral artery. In the limbs it is less dangerous.

IV. **Coagulating Injections.**—This method can only be employed in situations where the blood current can be arrested by pressure above and below the sac, say for one hour at least after the injection, and therefore cannot be applied in the case of innominate, aortic, or subclavian aneurism. The dangers are inflammation and abscess, and occasionally embolism. It may be

used after applying Esmarch's bandage, as in Dr Reid's method of compression and then injecting neutral ferric chloride or the fibrin ferment into the sac.

V. **Introduction of Foreign Bodies** into the sac (Moore), *e.g.*, fine iron wire or horse hair. This is supposed to hasten the formation of and entangle the fibrin of the blood, in the same way that whipping drawn blood with a bundle of twigs does. It has been used in some cases of aortic and subclavian aneurisms.

VI. **Galvano-puncture** (Dr John Duncan).—This may be used in some cases of internal aneurism, or aneurism at the root of the neck where other operations are contra-indicated. The positive pole is introduced into the sac; the current causes coagulation directly, and besides a certain amount of inflammation is set up which still further assists coagulation. Use a weak continuous current for ten or twenty minutes at a time. The same precautions must be adopted as in the introduction of coagulating injections lest it give rise to fatal embolism. The objections to its use are—(1) that it only produces a soft coagulum, which is apt to melt and the cure is thus rendered uncertain; (2) it is liable to set up severe inflammation of the sac and its contents; (3) the needles may produce eschars at the points of their insertion, and thus give rise to secondary hæmorrhage.

In the **treatment of aneurismal varix**, operation is seldom called for, as there is no true aneurism, and the disease has but little tendency to spread. It is chiefly a dilatation of *veins*, and it rarely tends to rupture or ulcerate—except in the lower extremity

where it may extend and occasionally ruptures, giving rise to fatal hæmorrhage, in the same way as varicose veins occasionally do. This condition may exist for the greater part of a life-time with but little change, especially in the upper extremity, and the rule is that if it is not advancing it should be left alone, so far as any operative measures are concerned. All that requires to be done is to give support to the distended vessels by Martin's bandage, elastic or laced stockings, &c. The different operative measures recommended for radical cure are—(1) Indirect pressure digital or instrumental; (2) flexion, but both these plans are probably of little use as there is no distinct sac, and therefore little tendency to the formation of a proper coagulum as in aneurism; (3) injection of coagulating fluids; (4) ligature of the artery above and below its communication with the vein. If aneurismal varix occurs within the skull, it may be necessary to resort to the Hunterian method, and ligature the common or internal carotid.

The **Treatment of a Varicose Aneurism** must be conducted on different principles. Here there is a constant tendency to increase in size, and it must not be left to take its own course as it will either become diffuse through the limb, or ulcerate and give way externally. Various methods have been proposed for its cure—(1) The 'old operation,' as in ordinary false aneurism answers very well, especially if it is done early enough, before the coats of the vessel have become so altered that they will not bear the ligature. Some recommend that the sac should not be opened, but simply isolate the artery and tie it above and below (Roux, Fergusson). In either case the special *dangers*

are—(*a*) Hæmorrhage from the part of the artery above the sac; (*b*) gangrene of the limb below the sac; (2) injection of coagulating fluids, such as a weak solution of neutral ferric chloride, with the usual precautions; (3) compression, direct and indirect; (4) galvano-puncture; (5) expectant, *i.e.*, do nothing; (6) amputation.

The **Treatment of Cirsoid Aneurism** requires great caution as the methods adopted often fail directly, or though for a time apparently successful, yet relapses are very frequent, and occasionally even a fatal termination has followed operations undertaken for the relief of this condition. Hence, unless the disease is advancing, and there is reason to fear that it may prove fatal from its extension or severity, it is advisable to avoid all operative measures. Many curative measures have been tried, but, on the whole, with little success; some of these may be enumerated—(1) Compression, a very doubtful proceeding; (2) ligature of the branches passing to the affected part, usually unsuccessful, on account of the free anastomoses; also ligature of the arteries on both sides of the mass; (3) extirpation *en masse*, by knife or ligature; (4) injection of coagulating fluids; (5) galvano-puncture. Dr Duncan, Edinburgh, who is one of the best authorities on galvano-puncture, has used it for the last twenty years, with remarkable and unvarying success, in the treatment of cirsoid aneurism.

CHAPTER III.

LIGATURE OF ARTERIES IN CONTINUITY.

Material of Ligature.—For a long time a single thread of **strong waxed silk** was the substance used. Usually one end of the ligature was cut close to the knot, and the other end left hanging out at the corner of the wound, and fixed there by a small piece of plaster; at the end of one or two weeks or more, as the case might be (depending on the size of the artery tied), when the healing process was completed, the ligature was pulled away. The security of the vessel was first ascertained by gently twirling the thread between the finger and thumb, when a yielding sensation indicated that the process was complete, and that the ligature might be safely removed without the risk of secondary hæmorrhage. Sometimes both ends of the silk ligature were cut short, and, in rare instances, it became encapsuled and gave no further trouble. The chief OBJECTIONS to the silk ligature are—(1) It is a foreign body in the wound; and (2) it separates by a process of ulceration or sloughing. For both these reasons the silk ligature is opposed to primary union, and may lead to complete or partial failure of the 'organisation' of the clot, and the other processes necessary for the permanent sealing of the ligatured artery. It is true that in favourable cases the lymph

and clot organise, and the divided internal and middle coats are blended together by firm fibrous union before the external coat is ulcerated through, and if this is the case then there is no danger of secondary hæmorrhage. In other cases, however, the ulcerative process extends faster than the healing process, and involves the clot which then breaks down, and there is thus a complete or partial failure of the organising process followed by secondary hæmorrhage when the ligature separates. Hence, in using the silk ligature there is always an uncomfortable feeling of uncertainty as to the final result, which only disappears when the ligature has separated and the wound healed. Next came the catgut ligature, introduced by LISTER, and for a time seemed all that could be desired; but by and by it was put aside because it sometimes disappeared before the vessel was perfectly sealed and secondary hæmorrhage was the result, and, further, if the wound putrified so did the ligature, and again the result was hæmorrhage. It has, however, been again revived, and is now used, but only after special preparation. At first it was prepared by being soaked for some months in carbolic acid, and the longer it was soaked the better it became; but it was found inconvenient to use a method of preparation that extended over such a lengthened period, hence the process now adopted is to soak it in a weak solution of chromic and carbolic acids for a couple of days, after which it is removed, stretched, and dried, and preserved in carbolic oil ready for use as required. The catgut is gradually absorbed when the process of healing is completed, and its disappearance is not accompanied by ulceration.

Other materials have also been used with success.

such as the middle coat of the aorta of the ox, cut into thin strips, and stretched to deprive it of excessive elasticity; it is kept in carbolised gauze, and before use it is steeped in carbolic oil, to render it pliable. The small tendons from the tail of the kangaroo are used for a similar purpose, and have the advantage of not requiring any previous preparation. In using the ox aorta ligature and the kangaroo tendons, the artery is compressed very gently and tied with a strong knot. They are said to be specially applicable in cases where there is a serious risk of secondary hæmorrhage, *e.g.*, near large branches, as in tying the first part of the subclavian, as they do not cut across the middle or internal coats, unless they are drawn very tight, and, further, the ligature lasts much longer than even chromic acid catgut, and is therefore to be specially recommended in circumstances, when, for special reasons, the artery must be tied at a place where its coats are diseased.

SPECIAL POINTS IN REFERENCE TO LIGATURE.

The chief points to be attended to in the ligature of arteries are the following—(1) To select a proper point for the application of the ligature; (*a*) it must not be too near the aneurism, because there the coats of the vessel are diseased; (*b*) it must not be too far away from the aneurism, for then the collateral circulation will be too quickly re-established through the sac and prevent the formation of a proper clot; (*c*) it must not be too near a large branch, for then the rush of blood would prevent coagulation at the point of ligature, and the other processes necessary for the organisation of the clot, and would ultimately give

rise to secondary hæmorrhage when the ligature separated. (2) To have a thorough knowledge of the general course and relations of the vessel, the more common abnormalities, as well as the recognised superficial and deep guides, in order to be able to mark out the vessel's course on the surface of the body; in short, the limb or other part being operated upon ought to be *transparent* to the Surgeon. (3) To make a *free* incision through the skin, and an equally free dissection down to the sheath of the artery, so as to lessen the depth of the wound as much as possible. Do not look for the artery in the first instance, but search for the various 'rallying points' one after the other, and the vessel will be reached in due time. The integument is to be gently stretched, without displacement, by the fingers of the left hand, and all large superficial veins avoided in making the first incision. A sharp scalpel should be used, and its point made to enter and leave perpendicularly to the surface to avoid 'tailing.' Twist or tie all bleeding vessels as you proceed, and above all things never hurry, but cut through layer after layer of the tissues covering the vessel, to the full extent of the original incision, in a calm and deliberate manner, carefully examining every layer with the eye and finger before cutting it. (4) Make a very limited opening in the sheath. Having cleared the sheath carefully from the structures covering it by means of the finger or director, take hold of it with the forceps and pinch up a small piece into the form of a cone, off the artery, and then cut into this cone by means of the scalpel, held flatwise, and on a plane just superficial to the artery. Take hold of that side of the opening in the sheath furthest from

you by a pair of Péan's forceps, in order not to lose sight of the opening, and take hold of the other edge with your dissecting forceps and clear a portion of the artery just sufficient to pass the point of the aneurism needle below the vessel. The clearing of the vessel well is one of the most important points of the operation. Too free separation of the sheath from the artery will endanger the vitality of the latter by the destruction of the *vasa vasorum*, which pass from the sheath to the coats of the artery; but, on the other hand, a small channel *must be cleared thoroughly* in order to pass the armed aneurism needle *easily*.

On this point the SAXON and the GAEL do not agree. The former, while admitting the necessity of separating the vessel from its sheath thoroughly and well, and at the same time doing the least possible injury to the *vasa vasorum*, believes that this end can be best attained by using a blunt director or some such similar contrivance; the latter, however, following the teaching and practice of the late Mr SYME, insist that the vessel can be most safely and effectually cleared by the use of the scalpel and forceps alone. Certainly Mr SYME's success in this branch of Surgery was greater than any other Surgeon of his time; he tied the femoral thirty-six times in succession without a single case 'going wrong,' and that, too, before the present improved method of treating wounds was known. Now the femoral at the apex of Scarpa's triangle is admittedly a difficult vessel to clear, and requires more than ordinary care; but if it can be best accomplished in the more difficult cases by the scalpel and forceps alone, how much more so in simple cases, like the brachial, for example. This is not in any sense a party

squabble: it involves a great principle and the truth, or otherwise, of this principle can only be tested by results. But are the results of the operation as performed by the former method, in any way superior to, or even as good as, those obtained by the simpler plan? We think not; and further, we believe that such instruments as directors, &c., are more likely to bruise the coats of the vessel and rupture an unnecessary number of *vasa vasorum.*

Mr Norton, in his excellent text-book of operative Surgery and Surgical Anatomy, following the French of Bernard and Huette, gives the following directions in reference to ligature of Arteries (the italics are mine) —'Raise the sheath with dissecting forceps, and divide it with precaution *sufficient only to introduce an aneurism needle.* Next lay aside the bistoury, and with the *director* and forceps free the vessel from the tissue around, taking care not to denude the vessel to too great an extent, and also to introduce the director between the vessel and the most important companion structure, in order not to wound that structure by the point of the director. When the artery is denuded and *raised upon the director* determine the pulsation, and then pass the ligature,' &c. By following these directions two results are likely to happen; either the coats of the vessel itself will be so bruised between the sharp edge of the sheath above and the director underneath—just as if it were between the badly-fitting blades of a shears—as to seriously endanger its vitality: or else the whole vessel will be so raised from its bed as to destroy the *vasa vasorum* for a considerable distance both above and below the opening in the sheath. It is difficult to see what good purpose is served by the

Surgeon raising the artery on the director — unless, indeed, it be to display the vessel to the admiring gaze of first year's students, and impress them with a due sense of his skill, and to congratulate himself and them, in pleased surprise, at the success of the operation. When Mr SYME was operating no one saw what he was doing, and certainly never saw the vessel, except the assistant standing opposite. Notwithstanding these obvious disadvantages, we would nevertheless advise students (although to do so is pandering somewhat to the spirit of the age), who intend to present themselves for examination at any of the examining boards of the sister country that require operations on the dead subject as part of the final examination, to rather adhere to the French method and make use of the director when ligaturing vessels, lest perchance you may offend a weak brother—and that 'weak brother' the presiding examiner.

(5) **On no account lift the vessel** from its bed, as to do so would endanger its vitality by destroying the delicate vasa vasorum, and pave the way for sloughing of the vessel and secondary hæmorrhage. The aneurism needle, armed with a strong waxed silk ligature, is passed through the aperture in the sheath and gently insinuated round the vessel till its point is just visible on the other side, and then the ligature is drawn out from the eye of the needle by a pair of forceps, while the needle itself is gently withdrawn. The handle of the needle must on no account be depressed, as this would raise the vessel from its bed: also great care must be taken not to slide the ligature up and down the artery, as in both cases the vasa vasorum would be destroyed. The needle should be passed from the

side where the chief dangers exist, and this, in large arteries, is usually where the vein is,—a noteworthy exception to this rule is seen in the case of the third part of the subclavian. In cases where the artery is accompanied by two veins the needle should be passed from the side on which the nerve is placed. It is recommended, when catgut is used instead of silk, to pass the unarmed needle till its eye is visible, then thread it with the ligature and withdraw. (6) Before finishing this part of the operation **compress the artery** between the finger and the curve of the aneurism needle, in order to make sure that no other structure, such as a nerve, for example, is included in the ligature as well as the artery, and note at the same time if this pressure stops the pulsation in the artery or sac beyond—this precaution is specially necessary in tying the subclavian in its third part. Carefully avoid in any way injuring the veins. (7) The ligature must be **tied transversely** round the artery, because if placed obliquely the knot tends to slacken. In tying press down the knot with the tips of the forefingers, and draw the noose moderately tight so as to divide the internal and middle coats of the vessel, and then tie again forming a reef knot. After tying a silk ligature one end is cut off close to the knot on the vessel, while the other is left hanging out of the wound; if catgut be used, then both ends are cut off close to the knot.

COMPLICATIONS AND THEIR TREATMENT.

The chief **unfavourable results** that may ensue from this operation are—(1) *Continuance or return of the pulsation* in the sac from misapplied or badly applied

ligature, *e.g.*, placed obliquely instead of transversely, or from the presence of a *vas aberrans*, or from a too free collateral circulation, or when the ligature is applied at too great a distance from the sac. (2) *Formation of another aneurism* at the next weakest point of the vascular system. (3) *Gangrene* of the limb, from the third to the tenth day, due to the too tardy establishment of an adequate collateral circulation to keep up the vitality of the limb beyond the aneurism, or from injury to the vein. (4) *Suppuration* and sloughing of the sac. (5) *Hæmorrhage* when the ligature separates, from disease of the coats, or sloughing of the included portion of the vessel before the ends have become permanently sealed by the reparative process; this may be caused by lifting the vessel from its bed or sliding the ligature up and down, and in this way destroying its nutritive supply.

The **treatment** after the operation should be mainly directed to avert the tendency to gangrene. The limb should be surrounded by a thick layer of carded wool to keep up its temperature, and elevated to assist the venous return. The diet should be moderately nourishing and stimulating, with the judicious use of opium, which not only soothes the patient, but also dilates the small arteries and capillaries, and thus assists the establishment of the collateral circulation. On no account should artificial warmth, in the form of hot bottles, be applied *to* the limb, as this would only hasten the gangrene.

CHAPTER IV.

ANEURISM OF THE THORACIC AORTA.

ALTHOUGH this part of the aorta, for obvious reasons, is never tied during life, still aneurism in some part of its course in the thorax is, unfortunately, by no means uncommon; and a knowledge of its relations to the surrounding structures is absolutely essential in order to interpret the leading symptoms. To point out these relations, therefore, and the chief untoward effects likely to be produced when these relations are interfered with by disease, will form a fitting introduction to the subject of ligature of special arteries.

FIRST, OR ASCENDING PART.—It *arises* from the base of the left ventricle at the level of the SIXTH DORSAL VERTEBRA behind, and the THIRD LEFT COSTAL CARTILAGE in front. From this point it passes upwards, to the right, and forwards and touches the sternum at the upper border of the SECOND RIGHT COSTAL CARTILAGE. This part of the arch is contained in the fibrous pericardium, and surrounded by a tube of the serous pericardium common to it and the pulmonary artery before its bifurcation; this depends on the fact that both vessels are developed from the *bulbus arteriosus* (*truncus communis arteriosus*) of the embryo. **Relations.**—*In front*—Pulmonary artery, pericardium,

right auricular appendix and chest wall. *Behind.*—Right pulmonary vessels and right bronchus. To its *right side*—Superior vena cava, and right auricular appendix. *Left side*—Pulmonary artery.

SECOND, OR TRANSVERSE PART.—This part extends from the SECOND RIGHT COSTAL CARTILAGE, passing transversely to the left, and backwards, to reach the left side of the body of the FOURTH DORSAL VERTEBRA. Relations.—It lies under cover of the left pleura, near its termination. *Above*—There is the left innominate vein, and the three large branches of the arch—(*a*) The innominate artery: (*b*) left common carotid; (*c*) left subclavian. *In front*—It is overlapped by the left pleura and lung, and then from left to right by the following nerves—(*a*) Left vagus giving off its recurrent laryngeal branch; (*b*) cardiac nerves to the superficial cardiac plexus (left superior cervical of the sympathetic, and inferior cardiac of left vagus); (*c*) left phrenic, crossing in front of the other nerves. *Below*—Pulmonary artery bifurcating, the obliterated ductus arteriosus connecting its left division with the aorta, superficial cardiac plexus, left recurrent laryngeal nerve and the left bronchus. *Behind*—Bifurcation of the trachea, deep cardiac plexus, left recurrent laryngeal nerve, œsophagus and thoracic duct.

THIRD, OR DESCENDING PART.—Extends from the lower border of the left side of THE BODY of the FOURTH DORSAL VERTEBRA, to the lower border of the left side of the body of the FIFTH DORSAL VERTEBRA. Relations.—*In front* the left pleura and lung, and partly also the root of the lung. It lies against the vertebral column, and to its *right side* we have the œsophagus and thoracic duct, but on a plane anterior

to it, while on the *left side* it is covered by the pleura and lung.

SYMPTOMS AND DIAGNOSIS.

The **general** means at our disposal for the diagnosis of aneurism of the aorta in the thorax, as well as its probable position, have been divided into direct and indirect. Fortunately this differential diagnosis as to the part affected, guides the special prognosis more than it modifies the treatment. The **direct** means of diagnosis include inspection, palpation, percussion and auscultation. *Inspection* may discover a bulging which may or may not pulsate or heave; *palpation* may show that the pulsation is expansile and not a mere upheaval, and may also detect thrills. *Percussion* indicates an increased area of dullness, and also the shape of that area, and its probable relation to the heart and great vessels. By *auscultation* we may hear the normal cardiac sounds very clearly in the sac, though they may be less clear between the sac and the heart; valvular murmurs may also be well heard, being transmitted by the blood current. At times also local murmurs produced in the sac are heard, being, as a rule, systolic in time. A very common effect of aneurism of the arch is to produce accentuation of the second sound in the aortic area. The **indirect** evidences are derived from the **pressure effects** on surrounding structures. (1) The *œsophagus*, causing difficulty in swallowing, especially of solids; on auscultating over the course of the œsophagus behind, delay in the transmission of the bolus may be detected. It may also be displaced to one side. (2) *Thoracic duct* producing rapid emaciation, anaemia, and sometimes ascites, the fluid poured

out resembling chyle. On account of the pressure on the duct the lymph and chyle that it normally conveys from the intestines to the blood is lost to the body, so far as nutrition is concerned, and hence the emaciation, on account of this great loss of fat, which may be discovered in the stools, causing fatty diarrhœa. (3) *Heart and blood vessels*—The heart may be displaced and its movements impeded, causing palpitation and other signs of heart disease; the arteries are usually imperfectly filled, and therefore show diminished tension, and there is also delay in the transmission of the pulse wave; the veins are overfilled, giving rise to œdema. (4) *Respiratory organs*—When the trachea is pressed on the patient has a feeling as if he were being throttled, and the respiration is noisy; this feeling is increased by exertion and excitement,—this is an important sign in the diagnosis of aneurism from ordinary tumours. There is a peculiar harsh, brassy cough but no expectoration, unless it has begun to ulcerate, when there will probably be hæmoptysis; the respiratory murmur will be feeble in both lungs. If only one bronchus is pressed upon the symptoms will be somewhat similar but confined to one side; there is also very frequently a harsh snoring heard over the part pressed on from the alteration produced in the size of the tube. There are no crepitations, nor is the vocal resonance increased, and therefore it differs from pneumonia. (5) *Nerves*—When nerves are affected we must distinguish two stages—(*a*) A stage of *irritation*, motor or sensory; and (*b*) the stage of *paralysis*. In *sensory* nerves there is at first severe shooting pains spreading in various directions along the nerve and its communications; this may be followed by complete or

partial anæsthesia. In *motor* nerves we first have spasmodic contraction of the muscles they supply, followed, sooner or later, by paralysis. As examples of the above, we have pressure on the CARDIAC nerves producing severe anginous pains; the PHRENIC, first irritated causing hiccough, later paralysed; RECURRENT LARYNGEAL, causing alteration of voice and dyspnœa from spasm of the muscles of the larynx during the stage of irritation, later aphonia from paralysis of the same muscles; on the VAGUS, causing severe anginous pains, nausea and retching, asthmatic dyspnœa, and probably inflammation of the lungs; the SYMPATHETIC during the stage of irritation causing dilatation of the pupil, but later, when the nerve is paralysed, contraction. (6) *Bones* are eroded and absorbed, and during the absorption there is severe pain, which is sometimes mistaken for rheumatism. The pain in the earlier stage is usually lancinating, intermittent, and neuralgic in character, and is probably due to pressure on the sympathetic or spinal nerves; it radiates in various directions—left side of head and face, left arm, &c. Later, the pain is more of a burning or boring character, and seems to depend on the absorption of the bony tissue and other compact structures. In the case of the vertebræ it may cause curvature of the spine, and lead to compression of the spinal cord, at first producing symptoms of motor and sensory irritation, gradually passing into paralysis of all the body below the level of the lesion. In attempting to distinguish between solid mediastinal tumours and aneurism, the following points should be kept in mind:—(1) In the case of aneurism the symptoms vary, being worse after excitement or exertion. (2) A solid tumour may have

a communicated impulse, but this impulse is never expansile. (3) Solid tumours neither reproduce the heart-sounds, nor do they give rise to sounds of their own. (4) In solid tumours it is very rare to find any difference in the pulses on the two sides of the body.

DIFFERENTIAL DIAGNOSIS AS TO THE PART AFFECTED.

Ascending Part.—On the anterior aspect it may appear as a pulsating tumour between the intercostal spaces on the right side of the sternum; there is increased dulness on percussion to the right of the sternum, and as the aneurism increases in size it may compress any or all of the structures in relation to it. In this part of the arch the aneurism rarely reaches a large size before it bursts into the pericardium, causing sudden death by filling it and stopping the heart. Should the aneurism be situated on the posterior aspect it may give rise to no symptoms except accentuation of the second sound in the aortic area, and delay of the radial pulse. **Transverse Part.**—When on the convex aspect it tends to pass to the right side of the sternum, or it may present at or above the manubrium sterni in the middle line; the cardiac plexus is frequently pressed on causing angina-like pains, and the voice is altered from pressure on the left recurrent laryngeal nerve simulating laryngitis or more serious laryngeal disease. Dyspnœa is an urgent symptom from pressure upon the trachea, bronchi, pulmonary veins or left recurrent laryngeal nerve; it may also produce cough and hæmoptysis and ultimately burst into the trachea, producing fatal hæmorrhage. It may further involve the thoracic duct or œsophagus, and cerebral disturbances

are common from interruption of the circulation through the carotid arteries; and when the innominate or left subclavian are involved there will be weakness and delay of the pulse at one or other wrists. It is very difficult to differentiate aneurism of this part from aneurism of one of the arteries at the root of the neck; but in the case of aortic aneurism the tumour is seen to have no defined lower boundary on percussion. There is usually well-marked œdema from pressure on the neighbouring veins. **Descending Part.**—The symptoms are obscure. There is dulness on percussion over the back or front, both to the left of the median line, and later the appearance of a pulsating tumour. There is marked erosion or absorption of the vertebræ, giving rise to severe pain referred either to the back or chest, and radiating round the intercostal nerves of the left side; pressure on the left bronchus or trachea and displacement of the left lung; pressure on the œsophagus causing dysphagia, probably the most distressing symptom of aneurism in this region. To these may be added the symptoms of pressure on the thoracic duct and veins of the chest-wall together with delay of the femoral pulse.

THE DESCENDING THORACIC AORTA.

This part of the aorta is the direct continuation of the aortic arch, and extends from the lower part of the left side of the body of the *fifth* dorsal vertebra (Turner), lower border of the *fourth* (Gray) to the anterior aspect of the *last dorsal* vertebra, where it leaves the thorax by passing through the aortic opening of the diaphragm. **Relations.**—*Behind*—It lies against the vertebral column following the dorsal

curve; it also crosses the vena azygos minor inferior, and sometimes the vena azygos minor superior. *In front* it is covered by the pericardium, crossed transversely by the root of the left lung, and very obliquely by the œsophagus. To the *right side* we find the œsophagus (at its upper part), vena azygos major, and thoracic duct. To the *left side*, the œsophagus (at its lower part), pleura and left lung. The relation that the **œsophagus** bears to the different parts of the aorta in the thorax is worthy of special note. It lies behind the transverse part of the arch, to the right of the descending part; to the right, then in front, and lastly to the left side of the descending thoracic aorta. These relations are to be specially remembered in cases of real or supposed stricture of the œsophagus, for both in stricture and aneurism there is marked dysphagia, and it is of the utmost importance to find out on what this depends. Occasionally in aneurism the patient has been treated for stricture of the œsophagus by the introduction of bougies, with the unfortunate and fatal result of perforation of the sac by the point of the instrument.

Note.—(1) The aorta in this part of its course, it will be observed, is covered by the left costal pleura: aneurism therefore in this part of the vessel is very apt to burst into the left pleural cavity by a large rent, giving rise to sudden and fatal hæmorrhage (when an aneurism opens on a *mucous* surface, the rent is seldom large, and death rarely so sudden as when it opens into a serous cavity). (2) The spinal column is pressed upon, the vertebræ are absorbed, and the cord may suffer, causing paralysis of the lower extremities. (3) The root of the left lung passes in front of the vessel, and

in the root the bronchus is the most posterior structure, hence this tube is narrowed, the lung therefore is imperfectly filled, and peculiar respiratory sounds are heard on auscultation. (4) The heart and pericardium are also in front, and the growth of the aneurism impedes the movements of the heart, and the disturbance thus caused may simulate heart disease. (5) There is dysphagia from pressure on the œsophagus (see the special relations of this tube to the aorta). (6) The thoracic duct is pressed on and may be obliterated, when there will be marked emaciation from the lymph and chyle lost to nutrition.

Although the aorta in this part of its course is not tied by the Surgeon, yet, curiously enough, nature herself can perform even this operation with success; for it is by no means uncommon to find the aorta obliterated just beyond the ductus arteriosus, or at the junction of the arch with the descending aorta, and yet the patient has survived. This is very interesting from a surgical point of view, as is shows the resources of the collateral circulation, and that it is possible to live, so far as that at least is concerned, even when the aorta is tied. According to Mr Sydney Jones, the principal communications by which the circulation was carried on, were—(1) The internal mammary anastomosing with the intercostal arteries, with the phrenic of the abdominal aorta, by means of the musculo-phrenic, and comes nervi phrenici, and largely with the deep epigastric. (2) The superior intercostal, anastomosing anteriorly, by means of a large branch with the first aortic intercostal, and posteriorly with the posterior branch of the same artery. (3) The inferior thyroid, by means of a branch about the size

of an ordinary radial, formed a communication with the first aortic intercostal. (4) The transversalis colli, by means of large communications with the posterior branches of the intercostals. (5) The branches of the subclavian and axillary going to the side of the chest were large and anastomosed freely with the lateral branches of the intercostals.

CHAPTER V.

LIGATURE OF THE INNOMINATE.

Instruments required in Ligature of Arteries.—Scalpel or straight bistoury, director, dissecting forceps, blunt hooks, a pair of broad, bent copper spatulæ, aneurism needles of various shapes, waxed silk, or chromic acid catgut ligatures, a pair or two of Péan's forceps, means to command the hæmorrhage, sponges, &c. **Assistants** required:—No. 1. To administer chloroform. No. 2. To hold and steady the limb, &c. No. 3. With a blunt hook in each hand holds apart the edges of the wound as layer after layer of the tissues are divided, and further, tries to lessen the depth of the wound as much as possible, putting the part into such a position as to relax muscles, &c. No. 4. With small sponges on the ends of sticks keeps the wound free of blood, and assists the operator to tie the bleeding vessels. No. 5. To hand instruments to the operator. No. 6. To wash sponges and hand them to assistant No. 4.

Innominate Artery.—This artery has also been named **Brachio-Cephalic**, from its being distributed to the arm and head. Aneurism of this vessel is extremely difficult to diagnose with certainty, as indeed are all aneurisms at the root of the neck. Many cases diagnosed as aneurism of the innominate during life,

have been discovered after death, by the more perfect light of the post-mortem room, to be aneurisms of the arch of the aorta. Aneurism of the innominate forms a pulsating swelling, usually situated on the tracheal side of the right sterno-mastoid muscle, and gives rise to certain SPECIAL SYMPTOMS, chiefly from pressure of the tumour on neighbouring structures. (1) The pulse on the affected side is small and feeble, and so is the pulsation in the right carotid. (2) The superficial veins of the neck are enlarged, and we have œdema of the right eyelid and arm. (3) There are dull aching pains (or they may be sharp and shooting) from pressure on, and irritation of the cervical and brachial nervous plexuses. (4) Dyspnœa from pressure on the recurrent laryngeal nerve, or by direct compression of the trachea. (5) Difficulty in swallowing. (6) If the cervical sympathetic be *irritated* there will be dilatation of the pupil of the affected side; but, if it be completely *paralysed*, the pupil on that side will be contracted. The same remark applies to aneurism of the common carotid.

Origin.—From the right side of the transverse part of the arch of the aorta. **Extent.**—From the above point to behind the right sterno-clavicular articulation and lower cervical region, where it bifurcates into the right subclavian and right common carotid. Its entire length is from $1\frac{1}{2}$ to 2 inches. **Course.**—Upwards and to the right, behind the first piece of the sternum. Its most important **relations** are: In *front*—(1) The first piece of the sternum. (2) Lower part of the sterno-mastoid, sterno-hyoid, and sterno-thyroid muscles. (3) It is crossed by the left innominate vein, and there is also a net-work of thyroid veins in front of it, em-

bedded in the loose cellular tissue. On its *right* side:—(1) The right innominate vein; (2) vagus; (3) phrenic; (4) pleura. On its *left* side, the left common carotid. *Behind*—(1) Trachea, at lower part; (2) pleura and apex of the right lung.

THE OPERATION.

In ligature of this vessel the **patient** should be in an easy recumbent posture, with the shoulders raised, the head thrown back and turned towards the left shoulder. The **Surgeon** may either stand in front of the right shoulder or behind the left.

Superficial Guide to the Vessel.—It lies just behind the right sterno-clavicular articulation. **Incision.**—The incision should be **V**-shaped. First make an incision about two inches long over the inner part of the clavicle and sterno-clavicular articulation to the sternum; another, two or three inches in length along the inner border of the right sterno-mastoid muscle, meeting the other at the sternum at an acute angle. By these incisions we divide—(1) Skin; (2) platysma and fascia; (3) sternal head and inner part of the clavicular head of the sterno-mastoid. These are thrown upwards and outwards, and then we cut through; (4) sterno-hyoid; and (5) the sterno-thyroid. The head is now drawn well back in order to draw up the artery into the neck as much as possible, the left innominate vein being fixed does not rise with the artery. **Deep Guide to the Vessel.**—Trace down the common carotid with the finger till the bifurcation of the innominate artery can be *distinctly felt;* then (6) draw the inferior thyroid veins carefully to one side, clear the vessel with the finger and director from the surrounding cellular tissue,

and ligature, taking care not to wound the pleura; the needle is passed *from* the *outer* side in order to avoid the right innominate vein and right pneumogastric nerve, and in passing it be careful to keep its point close to the artery, in order to avoid wounding the pleura covering the apex of the right lung.

The **Collateral Circulation** is practically the same as in ligature of the common carotid, added to that of ligature of the right subclavian (see Fig. 1).

PECULIARITIES.—As a rule, the innominate gives off no branch, but occasionally a small branch, the *thyroidea ima*, arises from it and runs up in front of the trachea to the thyroid body; further, it is by no means an uncommon arrangement to find the left common carotid joined with the innominate artery at its origin. In some cases there is no innominate artery, the right subclavian arising directly from the arch of the aorta, hence the importance and necessity of the 'deep guide,' viz.:—to trace down the common carotid with the finger till the bifurcation of the innominate artery is *distinctly felt*, and if this cannot be done, to desist from the operation or make some special explorations with a view to discover the reason why. Occasionally its point of division is considerably above the sterno-clavicular articulation, less frequently it divides below that point. When the aorta, as in birds, is a 'right aorta,' the innominate artery is on the left side of the neck instead of the right side. It will also be on the left side in cases of the rare congenital malformation of '*transposition*' of the thoracic viscera, when everything, as it were, lies on the wrong side.

Ligature of the innominate is not a successful operation, and can hardly be regarded as justifiable, and

is now practically abandoned, except for examination purposes. In a large proportion of cases (one-fifth of all) the operation has had to be abandoned, on account of unforseen difficulties, discovered only during its progress. To render the passing of the ligature more easy and certain, the inner end of the clavicle, and the upper part of the sternum may be removed (Cooper).

It is scarcely necessary to remind the reader that there is but *one* innominate artery (though there are two innominate veins), and that it is on the right side. It does not look well when a student rises from the examination table, (where he has sat down for his 'written,') and asks the examiner on *which* side he wishes the artery tied: it is apt to raise a *suspicion* (however unjust and unfounded that suspicion may be) in that gentleman's mind, that the student must have forgotten his anatomy considerably—if ever he knew it—of which fact he quietly makes a mental note for future reference. It is specially awkward to make *such* a mistake at *such* a time; for, if ever a student's words ought to be few and well chosen, it is at an examination.

TREATMENT OF INNOMINATE ANEURISM.

For the **treatment** of innominate aneurism various methods are adopted. All operative measures have, as yet, been very unsuccessful, the patients usually dying in a short time after the operation from secondary hæmorrhage, inflammation, and gangrene of the lung, or inflammation of the pleura: and, in all probability, death has in most cases only been hastened by the operation. We have—(1) *Medicinal and dietetic* treatment, the most trustworthy and safest method. (2) *Liga-*

ture of the innominate artery itself, usually of little use, and only hastens death. It can only, by any possibility, be successful if the artery is healthy and the aneurism limited; in tubular aneurism, where the coats are diseased, it is worse than useless, as the diseased artery gives way in a few hours under the pressure of the ligature, with fatal hæmorrhage. (3) Ligature on the *distal side of the aneurism* (BRASDOR and WARDROP). We may tie—(*a*) the subclavian alone; (*b*) the carotid alone; (*c*) both arteries, either simultaneously, or tie the carotid first and then the subclavian, after a longer or shorter interval—should the patient be fortunate enough to survive the first operation. Neither of these methods have been followed by any marked success, on account of the disturbance on the cardiac side of the ligature, which renders the probability of consolidation taking place in the sac all but hopeless; and, besides, the ligature is applied so close to the aneurism that the coats at the point of application are almost certainly diseased; the danger, therefore, of secondary haemorrhage is very great. (4) *Introduction of foreign bodies* into the sac, such as fine iron wire, horse-hair, or catgut.

CHAPTER VI.

SUBCLAVIAN ARTERY.

Origin.—On the *right* side from the branching of the innominate artery behind the sterno-clavicular articulation. On the *left* side directly from the arch of the aorta. **Extent** (in neck).—From the sterno-clavicular articulation to the lower border of the first rib. It is divided into three parts by the scalenus anticus muscle—a part internal to (1st part); a part behind (2nd part); and a part external to that muscle (3rd part). **Course.**—It crosses the lower part of the neck, taking an arched course over the apex of the pleura and first rib, passing between the anterior and middle scaleni muscles. It usually rises about one inch above the clavicle.

RIGHT SUBCLAVIAN.—First Part.

This part extends from the right sterno-clavicular articulation to the inner edge of the scalenus anticus muscle. An aneurism of the first part of the subclavian usually presents as a pulsating tumour external to the sterno-mastoid muscle. **Relations.**—*In front*—(1) Skin and superficial fascia; (2) Platysma; (3) deep fascia; (4) three muscles—sterno-mastoid, sterno-hyoid, and omo-hyoid; (5) three veins, internal jugular; vertebral, and anterior jugular; (6) three nerves—vagus, branches

of sympathetic (cardiac, and ansæ Vieusenii), and phrenic (the phrenic is always in front on the left side, and very often on the right side too, but usually close to the edge of the scalenus). *Behind*—(1) Longus colli muscle separated from it by loose connective tissue in which we find three nerves—the gangliated cord of the sympathetic, the recurrent laryngeal, and the cervical cardiac branch of the vagus. *Below* is the pleura and the recurrent larnygeal nerve. *Above*, there is nothing worth noting.

There are several grave **objections** to the ligature of this part of the subclavian—(1) Its great depth. (2) Its complicated relations; for these two reasons its ligature is one of the most difficult and serious operations in surgery. (3) Its shortness and the number of branches it gives off; it is only about one inch and a half in length, and gives off three large branches, so that its ligature is almost certain to be followed by fatal secondary hæmorrhage when the ligature separates. (4) When tied for spontaneous aneurism there is always the serious risk of the coats of the artery being diseased, so that they are unable to bear the ligature. (5) The disturbance both on the cardiac and distal side of the ligature render the formation of a sufficient coagulum all but hopeless. On the cardiac side there is the onward rush of blood in the innominate artery, and on the distal side there is the regurgitant stream through the vertebral, thyroid axis, internal mammary and superior intercostal. In almost every recorded case in which this operation has been performed, the patient has been carried off by fatal secondary hæmorrhage from the distal side, on the separation of the ligature, on account of the presence of these large

branches. But although it is such a dangerous and fatal operation, yet it is occasionally necessary to ligature the artery for examination purposes.

THE OPERATION.

In ligaturing the first part, the patient should be in an easy recumbent posture, with the shoulder depressed, the head thrown back, and the face turned to the opposite side; the Surgeon may either stand behind the opposite shoulder, or in front of the one on which he is to operate. An incision should be made transversely over the origin (sternal and clavicular) of the sterno-cleido-mastoid, and another, two or three inches in length, along the inner border of the same muscle, meeting the first incision at an acute angle. The V-shaped flap thus marked out, consisting of integument with the platysma and deep fascia, is then turned upwards and outwards. The sternal head of the sterno-mastoid, and part or whole of the clavicular head, is next divided on a director and turned outwards. Avoid the anterior jugular vein and its communications, and divide the sterno-hyoid and sterno-thyroid muscles in the same manner. Carefully separate the cellular tissue with the handle of the scalpel or the finger-nail, when the artery, with the internal jugular vein, will be brought into view. At the lower part of the wound the internal jugular vein inclines away from the artery leaving the pneumo-gastric nerve visible. The proper point for the application of the ligature is in the space between the vagus and the recurrent laryngeal nerve on the inner side, and the thyroid axis, phrenic and cardiac nerves on the outer side. The deep guide for the

securing of the vessel is to trace down the carotid to the bifurcation of the innominate, and then the subclavian artery is to be followed outwards till the vagus nerve is recognised by the finger. The internal jugular vein is pressed out of the way, and the nerves drawn aside in the direction indicated, the vessel cleared with the finger and director, and the needle passed from below upwards, but in doing so be careful not to injure the pleura or the right innominate vein, or include the vagus nerve. The subclavian vein is in front of the artery, and on a much lower level, being under cover of the clavicle and subclavius muscle, so that it is not likely to give any trouble during the operation. Occasionally, however, it rises in the neck as high as the artery, and in two cases it has been found accompanying the artery behind the scalenus anticus muscle.

LEFT SUBCLAVIAN.—First Part.

This vessel arises from the end of the transverse part of the arch of the aorta, and extends to the inner edge of the scalenus anticus. It differs from the right in being—(1) Much longer; (2) it is more deeply placed; (3) it ascends almost vertically upwards from its point of origin to its termination. **Relations.**—In **front**—(1) Left pleura and lung; (2) left internal jugular and innominate veins; (3) the same three muscles as on right side—sterno-mastoid, sterno-thyroid and sterno-hyoid; (4) the same three nerves as on the right side—pneumo-gastric, cardiac, and phrenic. It lies on a plane posterior to the left common carotid. **Behind**

It lies on—(1) Œsophagus; (2) thoracic duct; (3) sympathetic and cardiac branches (cervical) of

vagus; (4) longus colli muscle. To the inner side:—Œsophagus; (2) trachea; (3) thoracic duct. To the outer side, pleura and lung. It is generally taught that the relations of this part are too complicated to admit of ligature. Should it be found necessary to do so, the incision and the steps of the operation resemble the ligature of the corresponding part on the right side, but great care is necessary to avoid injury to the pleura and thoracic duct.

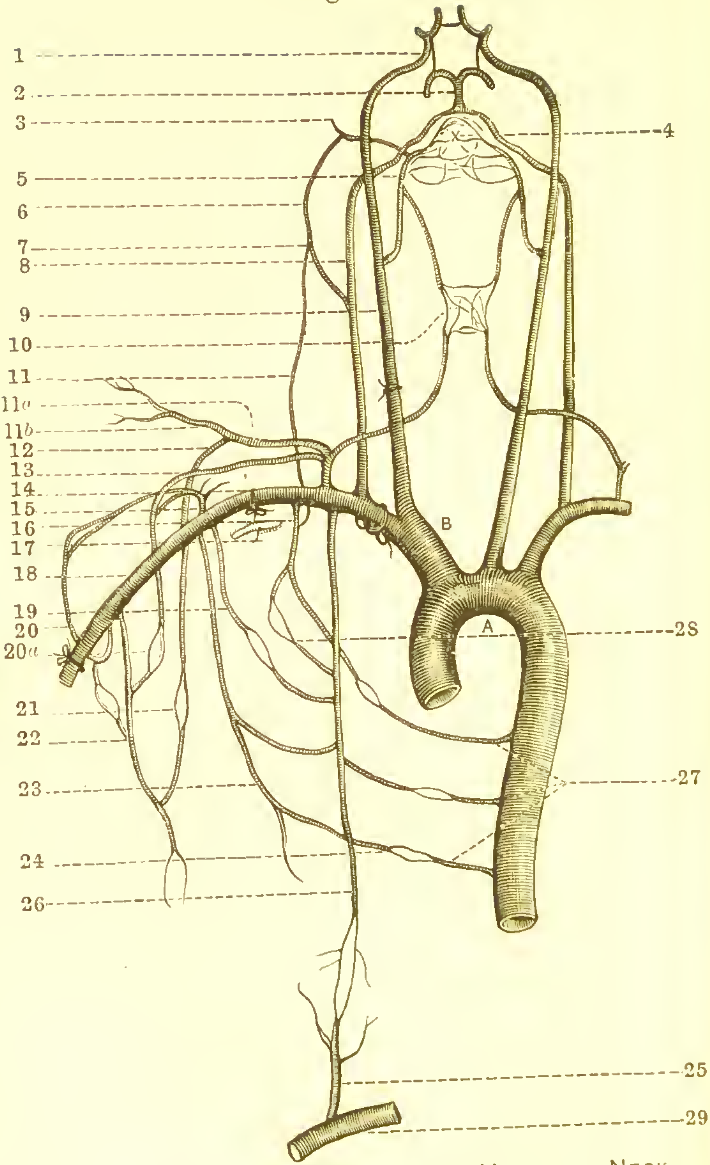
Collateral Circulation (Fig. 1).—When the **first part** is tied the following vessels re-establish the circulation:—(1) The superior intercostal (16) anastomosing with the aortic intercostals (27). (2) The inferior thyroid anastomosing with the superior thyroid (10). (3) By the inosculations of the vertebrals through the circle of Willis (1). (4) Internal mammary (26) anastomosing with the deep epigastric (25) and aortic intercostals (27). (5) The thoracic branches of the axillary (19, 23) anastomosing with the aortic intercostals (27). (6) The princeps cervicis (6) of occipital anastomosing with the profunda cervicis (11) from subclavian. (7) Branches from the thyroid axis going to the scapula (12, 13), anastomosing with the thoracics of the axillary (15, 19, 23), and through them with the aortic intercostals (27).

SECOND PART OF SUBCLAVIAN.—Right and Left.

This part of the artery lies beneath the scalenus anticus muscle, and is the shortest and highest of the the three divisions. It *may* be tied in this situation, but it is necessarily a dangerous and difficult operation.—(1) On account of the depth of the vessel. (2) Its close relations to the phrenic nerve, transversalis colli

[To follow page 50.

Fig. 1.



COLLATERAL CIRCULATION OF THE HEAD AND NECK
(After SMITH and WALSHAM).

Explanation of Fig. 1.

A. Aorta. B. Innominate artery.

1. Circle of Willis, formed by the posterior cerebrals from the basilar, and the anterior cerebrals from the internal carotids, connected together by the anterior and posterior communicating branches. 2. Basilar artery, formed by the union of the two vertebrals. 3. Occipital artery, from the external carotid. 4. To represent the anastomoses between the corresponding branches of the two external carotids, viz.—facial with facial, lingual with lingual, temporals with temporals, and occipital with occipital. 5. External carotid. 6. Princeps cervicis, from occipital. 7. Anastomoses between the princeps cervicis, vertebral and profunda cervicis in the region of the suboccipital triangle. 8. Vertebral, from the subclavian. 9. Common carotid. 10. Anastomoses between the two superior and the two inferior thyroids, in the region of the thyroid gland. 11. Profunda cervicis, from the superior intercostal. 11*a*. Transversalis colli. 11*b*. The superficial cervical. 12. Posterior scapular artery, one of the divisions of the transversalis colli branch of thyroid axis; the other division is called the superficial cervical and enters the trapezius. 13. Suprascapular artery from the thyroid axis, anastomosing with the subscapular from the axillary. 14. Subclavian artery. 15. Thoracic axis, from the axillary anastomosing with the supra-scapular and posterior circumflex. 16. Superior intercostal, anastomosing with the internal mammary and the aortic intercostals. 17. The first rib. 18. Axillary artery. 19. Superior or short thoracic, anastomosing with the internal mammary. 20. Posterior circumflex, anastomosing with the thoracic axis and the subscapular. 20*a*. Anastomosis between the suprascapular and the subscapular. 21. Anastomoses between the posterior scapular and the subscapular. 22. Subscapular artery. 23 and 24. Long thoracic, anastomosing with the internal mammary and the aortic intercostals. 25. Deep epigastric from the external iliac (29). 26. Internal mammary. 27. Aortic intercostals. 28. Anastomoses between the internal mammary and the superior intercostal.

and supra-scapular arteries; and (3) because it rests on the pleura and first dorsal nerve. On the **right** side it gives off one branch, the superior intercostal, and this is likely to interfere with the formation of a proper clot: on the **left** side it usually gives off no branch, the superior intercostal arising from the first part, on the left side. **Relations.**—In **front**—(1) Skin, fascia, and platysma; (2) sterno-mastoid; (3) branches of thyroid axis (transversalis colli and suprascapular); (4) phrenic nerve; (5) scalenus anticus muscle; (6) the subclavian vein is separated from the artery by the scalenus anticus, and is on a much lower level as a rule. **Behind**—(1) Pleura; (2) middle scalenus; (3) first dorsal nerve. **Above**, we have the brachial plexus, while **below** it rests on the pleura. Should it be necessary to tie this part, the vessel may be reached by means of the following **incisions**—a transverse one over the clavicular head of the sterno-mastoid, from two to three inches in length, and a vertical one about two inches long, rather external to the outer border of the sterno-mastoid, meeting the former at an acute angle. The flap thus mapped out, consisting of the integument platysma and deep fascia, is raised upwards and inwards, and the external jugular vein drawn outwards if necessary; the clavicular head of the sterno-mastoid is then divided from without inwards on a director, in order to expose the scalenus anticus. Lying on this muscle the following structures will very likely be seen—(*a*) the internal jugular vein along its inner border; (*b*) the transversalis colli and supra-scapular arteries; (*c*) the phrenic nerve; (*d*) in some cases also the external jugular vein along its outer border. These structures must be drawn aside in the

most convenient manner and carefully guarded from injury. The scalenus is next cautiously divided, from without inwards, to an extent sufficient to bring the artery into view, and after carefully clearing the vessel the aneurism needle is passed from below upwards. As a guide to the position of the scalenus anticus it is useful to remember that the outer edge of the sterno-mastoid almost corresponds to the outer edge of that muscle, though the scalenus is slightly external, and the external jugular vein often rests on the uncovered part.

Note.—(1) In dividing the scalenus anticus special care must be taken to avoid cutting or bruising the phrenic nerve which lies on its anterior surface, inclining obliquely towards its inner border. Two cases are mentioned by ERICHSEN, one in which the phrenic nerve was divided, and the patient died on the the eighth day of pneumonia; in the other case incessant hiccough followed the operation, and after death the phrenic nerve was found reddened and inflamed, having probably in some way been interfered with during the exposure of the vessel. (2) The transversalis colli and supra-scapular arteries also lie superficial to the scalenus anticus, and must be carefully preserved from injury, as they play a very important part in the collateral circulation. (3) The confluence of the internal jugular and subclavian veins is also commonly in front of scalenus anticus. (4) On the left side the thoracic duct will be found arching downwards in front of the scalenus anticus and phrenic nerve. On the right side a corresponding structure, the right lymphatic duct, may also be found, but it is usually very small.

THIRD PART OF SUBCLAVIAN.—RIGHT AND LEFT.

This is the part most frequently ligatured, because—(1) It is the most superficial part; (2) it is the longest part; (3) it is usually free from branches; (4) the first rib is interposed between it and the pleura, and by passing the needle as the artery lies on the first rib, we avoid wounding the pleura, and will also usually avoid coming into contact with any abnormal arterial branches—as these usually arise close to the outer edge of the scalenus anticus. It extends from the outer edge of the scalenus anticus muscle to the lower border of the first rib, and is contained in a small triangular space, the lower and smaller of the two divisions of the posterior triangle, bounded by the sterno-mastoid in front, the clavicle below, and the posterior belly of the omo-hyoid above. **Relations.**—In **front**—(1) Skin superficial fascia, platysma, and deep cervical fascia. (2) A plexus of veins formed by the external jugular and its tributaries, in this region, viz., suprascapular, transversalis colli, and frequently also a communication from the anterior jugular, and another from the cephalic vein. (3) Descending branches of the cervical plexus of nerves. (4) Nerve to subclavius. (5) Clavicle and subclavius muscle. (6) Supra-scapular artery. (7) The subclavian vein, but at a much lower level. **Above**—(1) The cords going to form the brachial plexus. (2) The posterior belly of the omo-hyoid. **Behind**—The scalenus medius. **Below**—The first rib, and partly also, the nerve trunk formed by the union of the 8th cervical and 1st dorsal nerves. The same nerve cords also lie behind it. The artery is sometimes described as lying in the lower part of a little triangle

formed thus—internally it is bounded by the outer margin of the scalenus anticus, externally by the scalenus posticus, the convergence of these two muscles forming the apex of the triangle, the base being formed by the first rib on which the vessel rests (SPENCE). In the same triangle, above and behind the artery, are the cords going to form the brachial plexus.

THE OPERATION.

The **patient** should be in the recumbent position, with his shoulders supported by pillows, his head thrown backwards and his face turned to the opposite side, while the arm of the affected side is to be depressed as much as possible so as to lessen the depth of the wound. The **Surgeon** may either stand behind or in front of the shoulder on which he is to operate.

Superficial Guide.—The vessel lies beneath the most prominent part of the clavicle, and it is important to remember, that by pressing the thumb, or a padded key, firmly downwards and backwards behind that point of the clavicle, towards the first rib, the vessel may be compressed during life, and the circulation through the upper limb entirely commanded. **Incision.**—With the inner side of the left hand draw down the skin over the clavicle for about one inch, and cut *along the bone* for two and a half or three inches, beginning over the clavicular origin of the sterno-cleido-mastoid and ending at the trapezius; by drawing down the skin in this manner one is less likely to cut the external jugular vein, which may be found in any part of the base of the posterior triangle, and perforates the deep fascia about half an inch above the clavicle. This incision corresponds to the middle third of the clavicle,

or base of the posterior triangle. But, further, to simplify matters, especially if there is reason to suppose that the artery lies deeper than usual, it is advisable to make another incision two inches in length, along the outer edge of the sterno-mastoid joining the former incision nearly at a right angle, more especially in cases where the shoulder cannot be depressed, in very fat people, or those with short thick necks. **Parts cut through.**—While the skin is tense over the clavicle there is divided *on* the bone—(1) Skin. (2) Superficial fascia. (3) Platysma. (4) Superficial nerves and vessels—the nerves are the descending branches of the cervical plexus; the vessels are chiefly the tributaries of the external jugular vein, which at this point usually form a venous plexus in front of the subclavian artery. The external jugular vein should be now exposed and saved by drawing it inwards or outwards according to circumstances; but if too much in the way, it should be secured by two ligatures and divided between them. When the tension is taken off, and the wound thus moved a little above the clavicle, we then cut through (5), the deep fascia in the middle of the wound, that part of the cervical fascia which binds down the posterior belly of the omo-hyoid to the clavicle. Next seek for the interval between the omo-hyoid (posterior belly) and the clavicle which will probably be about an inch in extent, but may be more or less. The knife must not be allowed to pass beneath the clavicle, lest the subclavian vein or the supra scapular vessels be injured. Take care also of the transversalis colli artery, as both it and the supra-scapular are important agents in the collateral circulation; and, besides, if the supra-scapular be injured it is often difficult to secure, from

the dense fascia in this situation and its being partly under cover of the clavicle. Push the omo-hyoid upwards a little, and with the finger or the handle of the knife scratch away any intervening areolar tissue, with a lymphatic gland and the other structures lying over the artery, and define the outer edge of the scalenus anticus muscle, and follow it down to its insertion into the first rib. (6) The small nerve to the subclavius muscle also crosses in front of the artery near its middle. At first sight the division of this small nerve may seem a matter of little consequence, still it is important to remember that it very frequently has a communication with the phrenic nerve, and may give rise to unpleasant symptoms if it be lacerated, from the reflex irritation and the summation of the stimuli, starting from the lacerated point.

Deep Guide to the Vessel.—Either the tubercle on the first rib at the insertion of the scalenus anticus and the outer edge of the same muscle, when the artery will be found immediately above, and a little behind it, but covered and bound down to the first rib by a sheath of dense cervical fascia. When the tip of the finger touches the tubercle, the pulp of the finger will rest on the artery (SPENCE); or, the three white cords going to form the brachial plexus seen at the outer end of the wound, and which are placed above, and a little behind the artery—the artery being between them and the first rib. (7) Open the sheath, and with the forceps and director* clear the vessel, and pass the aneurism needle from *above* so as to avoid the nerves going to

* In this, and many of the other operations for ligature of arteries, I have directed that the artery is to be cleared with the aid of a director, not because I believe that such a method should be employed, but simply to keep the student in mind that this plan is adopted by many Surgeons.

form the brachial plexus, which are far more liable to be included in the ligature than the vein, which is to the front of, and considerably below, the artery. Still it is but right to state that many Surgeons recommend that the ligature should be passed from below upwards. The needle most suitable for passing the ligature is 'a common aneurism needle with a considerable curve' (BELL). It should be passed as low as possible, as the vessel lies *on* the first rib. It is advised, in cases where it is impossible to ligature the artery for want of space, to cut through the clavicle, provided it does not form part of the wall of the aneurism. One of the principal causes of death after ligature of the subclavian is septic inflammation, starting in the areolar tissue, and spreading to the anterior mediastinum, pericardium, and pleura. This is due to the opening up of the layers of fascia prolonged from the neck into the thorax, and more or less fixed to the inner side of first rib, and partly forming a roof to the pleural cavity. The opening up of this roof is the more likely to happen if the artery be tied anywhere else than *on* the first rib.

Note.—(1) In thick-set, short-necked persons the artery is usually deeply seated; it may be below the level of the clavicle, or but slightly above it. (2) In thin, long-necked persons its course is usually high, and, therefore, is much more easily reached and ligatured. (3) The clavicle in some cases is very much curved. When this is the case, the depth of the vessel from the surface is increased, and is therefore more difficult to ligature. An aneurism in the axilla will produce the same effect (by raising the clavicle), and tends to complicate the operation considerably, as the

shoulder cannot in this case be depressed, a similar result may be produced by emphysema of the lung. (4) The artery may pass in front of, or through the anterior scalenus; the clavicular head of the sterno-mastoid, instead of being confined in its origin to the inner third of the posterior surface of the clavicle, may pass beyond its usual limit outwards along the clavicle, and conceal the artery; and the trapezius may also pass further inwards than it usually does, and overlap the artery. In 5 per cent. of the cases, the omo-hyoid arises from the middle third of the clavicle, and, therefore, covers the artery. (5) The posterior scapular artery frequently, and sometimes the supra-scapular, may spring from this part. (6) The external jugular vein should lie on the outer edge of the sterno-mastoid; but, very frequently, it is more external, and passes beneath the deep fascia just above the middle of the clavicle, crossing the third part of subclavian artery, and emptying itself into the subclavian vein. While it it lies over the artery it receives the suprascapular and transversalis colli veins, and in this region also communicates with the anterior jugular and cephalic veins. In this way a plexus of veins is formed in front of the artery. If any of the large venous trunks must be cut in the operation, a double ligature should be applied and the vein divided between. The subclavian vein may rise as high as the level of the clavicle, or may lie with the artery beneath the anterior scalenus. (7) A cord formed by the 8th cervical and 1st dorsal nerves lies immediately behind the subclavian artery—or may be between it and the first rib—and is, therefore, specially liable to be included in the ligature, or even to be tied instead of the artery—mistakes committed by several

eminent Surgeons. (8) In some cases the suprascapular artery is much enlarged, and has been mistaken for the subclavian. (9) Aneursim of the transversalis colli may simulate subclavian aneurism.

Collateral Circulation, when the subclavian is tied in its second and third parts (fig. 1)—(*a*) The suprascapular (13) from thyroid axis (first part of the subclavian) anastomosing with the dorsalis scapulæ branch of the subscapular (22) (from third part of axillary). (*b*) The posterior scapular branch of the transversalis colli (12), of thyroid axis, anastomosing with the subscapular (22) and circumflex branches (20) of axillary. (*c*) Internal mammary (26) from first part of subclavian, the superior intercostal (16) and the aortic intercostals (27), anastomosing with the long and short thoracics of axillary artery (23, 19), and the deep epigastric (25).

IRREGULARITIES.—The right subclavian may spring as a separate trunk from the arch of the aorta, and when it does so, the first part is much deeper than usual. It may pass in front of or through the fibres of the scalenus anticus; and its point of origin varies according to the point of bifurcation of the innominate. When it springs directly from the arch it may be the first, second, third, or even the fourth branch. When it is the first it occupies the position of the innominate; when it is the second or third it usually passes behind the right carotid to gain its usual position; and when it is the last branch it may pass behind the œsophagus, or between it and the trachea, to reach its ordinary position. The left subclavian is sometimes joined with the left common carotid at its origin. An instructive case is related by Mr HOLMES, where, in a case of

aneurism of the arch of the aorta, the pulsation in the right carotid was normal, but the pulse at the right wrist was obliterated. The explanation was that, in this case, the subclavian arose as the last branch from the arch, and in order to reach its usual position it passed between the arch and the spine, against which the aneurism compressed and obliterated it.

Treatment of Subclavian Aneurism.—(1) *Medical and dietetic*, combined with rest, &c. (2) *Surgical measures;* but all operative measures are more or less dangerous or uncertain—(*a*) In aneurism of *first* or *second* parts, pressure on the vessel at the distal side of tumour against the first rib may be tried: (*b*) in the same condition ligature of the third part above or below the clavicle may be tried—Brasdor's plan, or distal ligature; (*c*) ligature of the innominate if the aneurism be limited; (*d*) or amputation at the shoulder joint and tying the artery on the face of the stump (Fergusson). In aneurism of the *third* part we may—(*a*) Ligature the first part, using ox aorta or kangaroo tail tendons, so as rather to compress the vessel than to divide its coats; (*b*) direct pressure on the tumour with refrigeration; (*c*) amputation at shoulder joint. Other means, equally uncertain and dangerous, such as galvano-puncture, manipulation, and introduction of foreign bodies have been tried.

BRANCHES OF THE SUBCLAVIAN.

OF THE FIRST PART.—I. Vertebral.—It arises from the upper surface of the artery, passes up beneath the internal jugular vein, between the longus colli on the inner side, and scalenus anticus on the outer side, to the foramen in the transverse process of the sixth

cervical vertebra. It is crossed by the inferior thyroid artery on both sides, and on the left side, in addition, by the thoracic duct. This vessel was first ligatured by Dr SMYTH of New Orleans; and, more recently, the operation has been recommended by Dr ALEXANDER of Liverpool, in epilepsy. We append Dr SMYTH'S description of the operation as performed by himself:—'The head of the patient being thrown back and slightly turned to the left, an incision two inches in length was made along the posterior border of the sterno-mastoid muscle, commencing at the point where the external jugular vein crosses this muscle, and terminating a little below the clavicle, the edge of the muscle being exposed and drawn to the inner side, the prominent anterior tubercle of the transverse process of the sixth cervical vertebra was readily felt and taken for a guide. Immediately before this, and in a vertical line with it, lies the artery. A layer of fascia was now divided, some loose cellular tissue with lymphatics, and the *ascending cervical* artery were pulled to the inner side, and a separation was made between the scalenus anticus and longus colli muscles just below their insertion into the tubercle, when the artery and vein became visible, the latter was drawn to the outer side (this is important), and the needle passed around the former from without, inwards.'

Note.—The prominent anterior tubercle of the transverse process of the sixth cervical vertebra is known as the '*carotid tubercle*' of CHASSAIGNAC, and by some Surgeons is used as the 'deep' guide in ligature of the common carotid artery as well as in ligature of the vertebral. It is about two inches above the clavicle, or on a level with the cricoid cartilage.

On the *left* side the operation is more difficult and dangerous than on the right, on account of the presence of the thoracic duct. This structure rises in the neck as high as the sixth cervical vertebra, passing outwards *behind* the internal jugular vein and *lying on* the vertebral artery and vein (or very frequently between them) the anterior scalenus, the suprascapular and transversalis colli arteries, and phrenic nerve. It then curves downwards and inwards to enter the left subclavian vein at its junction with the left internal jugular.

II. **The Thyroid Axis.**—This is a short trunk very soon dividing into three branches—(*a*) **Inferior Thyroid**, which passes upwards and inwards in *front* of the vertebral artery, recurrent larnygeal nerve, and longus colli muscle, but *behind*, the carotid sheath and its contents, and the gangliated cord of the sympathetic. It takes a flexuous course to the inferior angle of the thyroid body. If this branch is ligatured as it passes behind the carotid sheath, the incision and the structures divided will be nearly the same as in ligature of the common carotid at the lower part of the neck, the necessary modifications being evident. As the omohyoid partially conceals the vessel, it must be drawn aside or divided; when this is done, look for the artery between the trachea and the œsophagus on the inner side and the carotid sheath with its contents, on the outer side. In performing this operation great care must be taken not to injure the descendens noni or recurrent laryngeal nerves. In excision of the thyroid body, this vessel requires to be ligatured as it enters the inferior angle of the gland. The branches of the inferior thyroid artery are—(1) Ascending cervical; (2) inferior

laryngeal branch; (3) œsophageal; (4) tracheal. (*b*) **Transversalis Colli**—Passes outwards in front of the scalenus anticus and phrenic nerve, and beneath the sterno-mastoid, into the posterior triangle of the neck, where it passes in front of the cords going to form the brachial plexus, and ends there by dividing into superficial cervical and posterior scapular arteries. Aneurism of this branch may simulate subclavian aneurism. (*c*) **Suprascapular, or Transversalis Humeri**—This vessel is on a lower level than the last, and runs outwards in front of the scalenus anticus and phrenic nerve, but behind the clavicle and the omo-hyoid to the upper border of the scapula. In some rare cases this branch is much enlarged, and has been mistaken for the subclavian artery itself.

III. **Internal Mammary.**—This vessel passes downwards behind the inner end of the clavicle, and the beginning of the right innominate vein, and enters the chest between the first rib and the pleura; as it is about to enter the chest, it is crossed by the phrenic nerve, and covered by the internal jugular and subclavian veins. If this vessel were to be tied at its origin, it should be borne in mind that its anterior relations are precisely similar to those of the first part of the subclavian (*quod vide*). For the rest of its course it lies fully half an inch external to the margin of the sternum, and in the interval between the sixth and seventh costal cartilages it ends by dividing into the *musculo-phrenic* and *superior epigastric*. In *front*, the internal mammary is covered by—(1) Skin, superficial and deep fascia; (2) pectoralis major; (3) anterior intercostal membrane; (4) internal intercostal muscle; (5) costal cartilages. It *lies on*—(1) Triangularis sterni;

(2) costal pleura; (3) terminations of the intercostal nerves. The *left* internal mammary is usually described as being one of the contents of the anterior mediastinal space, but such is not the case, as in no part of its course does it lie within that space (CUNNINGHAM). For the purpose of ligature the vessel may be reached by an oblique incision downwards and outwards from the side of the sternum, the centre of the incision being half an inch from that bone; then by dividing the various muscular and fascial layers already indicated, the artery, with its accompanying veins, can be readily exposed. In cases, however, of hæmorrhage from the artery, the result of a wound, the operation of securing the vessel may be more difficult, but the bleeding may be readily controlled by compression, as in the case of an intercostal artery; a small bag of muslin, or a fine silk handkerchief, being introduced through the wound is stuffed with lint or a piece of sponge, and then withdrawn so as to effectually compress the vessel against the costal cartilages.

OF THE SECOND PART.—The superior intercostal artery, and arising in common with it is the profunda cervicis branch, which passes back between the neck of the first rib and the transverse process of the seventh cervical vertebra, and ascends in the neck between the complexus and the semi-spinalis colli, supplying these muscles and anastomosing with the vertebral and princeps cervicis branch of the occipital artery. On the left side, as already mentioned, the superior intercostal arises from the first part of the subclavian. In either case it descends into the thorax in front of the neck of the first rib, and gives off the posterior intercostal arteries to the first and second spaces, anastomosing

with the first aortic intercostal and the internal mammary. The inosculation between the *profunda* and the *princeps cervicis* is an important agent in re-establishing the circulation after ligature of the common carotid.

CHAPTER VII.

CAROTID ARTERIES.

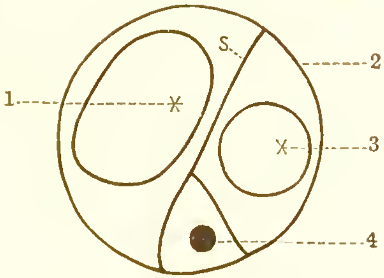
Common Carotid Artery.—Aneurism of this vessel presents as a pulsating tumour between the two heads of the sterno-mastoid, and gives rise to certain special pressure symptoms; for instance, if the aneurism be situated near the bifurcation of the vessel (where it usually occurs), there is a constant hacking cough due to pressure on the superior laryngeal nerve; if it be placed lower down we may get spasm of the glottis from pressure on the recurrent laryngeal nerve. There may also be serious dyspnœa and difficulty in deglutition from direct pressure, and also from irritation of the pharyngeal plexus.

Origin.—On the *right* side in the bifurcation of the innominate artery opposite the sterno-clavicular articulation. On the *left* side it springs directly from the arch of the aorta. **Extent.**—From behind the sterno-clavicular articulation to a point, a little higher than the upper margin of the thyroid cartilage, where it divides into internal and external carotids. **Course.**—Its course is indicated by a line drawn from the sterno-clavicular articulation to a point midway between the angle of the jaw and the mastoid process.

The artery, together with the internal jugular vein and vagus nerve, are included in a common sheath

derived from the deep cervical fascia, although each structure lies in a separate compartment; the septa are comparatively strong, especially that between the vein and the artery. This is important, because the compartment containing the artery may be opened without interfering with those containing the vein and nerve, and in this way the vein, which is about twice the size of the artery, is prevented from bulging over that vessel during the operation. In the sheath the artery is the most internal, the vein most external, and the nerve behind and between (Fig. 2). Before describing

Fig. 2.



TRANSVERSE SECTION OF LEFT CAROTID SHEATH.

1. Internal jugular. 2. Point at which the sheath should be opened in ligaturing the common carotid artery. 3. Common carotid artery. 4. Pneumo-gastric nerve. S. Septum between the artery and vein.

the operation itself, we will state very briefly the chief relations of the sheath to the surrounding parts.

As high as the **Cricoid Cartilage** it is deeply placed, and is covered by—(1) The common investments (*i.e.* skin and superficial fascia, platysma and deep fascia). (2) Sternal head of sterno-mastoid. (3) Sterno-hyoid. (4) Sterno-thyroid. (5) Crossed by omo-hyoid. (6) Above this point it enters the carotid triangle, and is merely covered by the common investments of the

parts, and crossed, about the point commonly chosen for the application of a ligature, by the sterno-mastoid artery from the superior thyroid. It is also crossed by (7) three veins—superior and middle thyroids, and anterior jugular. (8) The descendens noni lies on (sometimes in) the sheath. (9) In front of the superficial part there are some lymphatic glands; it is important to remember this, as a gland may be mistaken and cleaned for the artery in the heat of the operation. Further, these glands are apt to suppurate and may simulate aneurism. (For the diagnosis between aneurism and abscess, see p. 6). It is usually slightly overlapped by the sterno-mastoid at its upper part. Behind the sheath is—(1) the gangliated cord of the sympathetic; (2) the recurrent laryngeal nerve crossing obliquely inwards behind the sheath; (3) longus colli; (4) rectus capitis anticus major; and behind these (5) the transverse processes of the cervical vertebræ, against which the vessel may be compressed during life. (6) The inferior thyroid artery also crosses obliquely inwards behind both the sheath and the gangliated cord of the sympathetic. (See 'Branches of Subclavian.') (7) Behind the deep part of the sheath are some lymphatic glands. To its inner side we have—(1) The larynx and trachea. (2) Pharynx and œsophagus. (3) Thyroid body. (4) Recurrent laryngeal nerve and inferior thyroid artery. To the outer side, a chain of lymphatic glands and the scalenus anticus. The above are the chief relations of the carotid sheath. To assist the memory note the following points in regard to the relations of the artery itself:—(1) That there are four muscles in front of it, viz., sterno-mastoid, sterno-hyoid, sterno-thyroid, and omo-hyoid. (2) That

there are four veins in relation to the artery—two jugular, and two thyroid, three of these cross it, and one (the internal jugular) lies to its outer side. (4) That there are four nerves in relation to it—*above*, the descendens noni; *behind*, the gangliated cord of the sympathetic; on the *inner* side, the recurrent laryngeal (at its lower part); on the *outer* side, the vagus.

It may be necessary to ligature this vessel for a wound, either of itself or its branches, for aneurism, for epilepsy, for pulsating tumours of the orbit and skull, or aneurism by anastomosis of the scalp. As it gives off no branches it may be tied at any part of its course, but it is better to avoid tying it either close to its origin or to its termination—at its origin, on account of its great depth, and especially on the left side where the internal jugular vein is in front and the thoracic duct behind it: at its termination, because here there is a large plexus of veins in front of it. If for a wound, it must be tied on both sides of the bleeding point; if for a wound of its branches, or pulsating tumour higher up, it should be tied in the most accessible position—above the omo-hyoid; if for an aneurism, the point of ligature will depend on its position, *e.g.*, in aneurism of the upper part, the HUNTERIAN operation may be used, while in aneurism low down we may use the method suggested by BRASDOR.

LIGATURE ABOVE THE OMO-HYOID

The patient should be placed in the recumbent position,and his chest raised by means of pillows, the head being thrown back a little, and the face turned towards the opposite shoulder, in order to make the sterno-mastoid tense and prominent, and the angle of the jaw

turned up somewhat. The neck should be compressed at the lower part, in order to make the superficial veins turgid, and their course noted, so that they may be avoided as much as possible in making the necessary incision. The **Surgeon** should stand at the same side as the vessel about to be ligatured, and most conveniently behind the shoulder.

Superficial Guide.—The line marking its course, or the anterior border of the sterno-mastoid. **Incision.**—With the line of the vessel in mind, make an incision three inches in length, so arranged that its centre shall be on a level with the cricoid cartilage—the point usually selected for ligature above the omo-hyoid. The upper part of this incision will be a few lines *nearer* the middle line of the neck than the anterior margin of the sterno-mastoid, this muscle diverging from the artery as it rises higher in the neck. By this incision we divide—(1) the skin; (2) superficial fascia; (3) platysma; (4) then cut through the deep fascia and expose the edge of the sterno-mastoid, and draw it aside with blunt hooks, the head being previously turned a little towards the same shoulder and flexed, in order to relax its fibres. (5) Expose omo-hyoid by cutting through a dense fascia, covering it and the other muscles and carotid sheath. It is of importance to note that at this part of its course there is usually a large venous plexus in front of the vessel, formed chiefly by the superior thyroid veins with communications from the lingual facial, anterior, and external jugulars. (6) Draw aside the lateral lobe of the thyroid body which is now exposed, and look for the **deep guide** to the vessel, viz., the angle formed by the anterior belly of the omo-hyoid with the anterior border of the sterno-mastoid—the

artery bisecting this angle. Draw the muscle inwards with a blunt hook, and then expose the sheath fully, by carefully turning aside any intervening structures with the *handle* of the knife, using the blade as little as possible, in order that the descendens noni nerve and its communications, and sterno-mastoid branches of the superior thyroid artery be not injured. Open the *inner* compartment of the sheath (fig. 2), clear the artery very thoroughly, and pass the ligature (without using force) from the *outer* side to avoid the risk of wounding the internal jugular vein or including the vagus, holding the other edge of the opening in the sheath, with a pair of artery forceps to steady it during the passage of the ligature.

LIGATURE BELOW THE OMO-HYOID.

Right Side.—If we wish to ligature the vessel below the omo-hyoid, it is necessary—(1) That the incision be extended further down along the anterior edge of the sterno-mastoid, which must be drawn well outwards, after having divided its sternal head. An incision three inches long commencing a little above the level of the cricoid cartilage, and extending to the episternal notch, will be found sufficient. (2) To divide the fascia binding the omo-hyoid to the muscles near it, and draw it upwards. (3) Draw the sterno-hyoid and sterno-thyroid muscles inwards (or, if necessary, divide them), and the carotid sheath is now exposed. Proceed as in ligature above the omo-hyoid, bearing in mind the complicated relations of the parts (*see before*). There is a venous plexus in front of the vessel formed chiefly by the middle thyroid veins, with communications from the anterior and external jugulars;

the chief trunks must be carefully avoided, as well as the ansa hypoglossi and its branches. On the **left** side the artery springs from the arch of the aorta, but beyond the sterno-clavicular articulation, its relations are almost the same as those of the vessel on the right side, with the following differences:—(1) It is more deeply placed. (2) The internal jugular vein and the pneumogastric nerve are often placed in front of the artery in the lower third of the neck. This makes clearing the vessel for the passage of the ligature more difficult on the left side; on the right side it is easy, because the vein inclines away from the artery at its lower part, but on the left side it bulges right over the vessel, and in the living subject complicates the operation considerably. (3) It is nearer the œsophagus. (4) Low down, the thoracic duct lies to its outer side. Otherwise the operation for ligature of the vessel on the left side is similar to the corresponding operation on the right side. After the operation the patient should be placed in bed with the head and shoulders raised. His head should be bent a little forwards to relax the parts, and fixed in that position by a circle of bandage round it, with strips passing from it to be fixed to a broad band round the chest. An opiate, or a mixture containing hydrocyanic acid, may be necessary to allay laryngeal irritation.

Collateral Circulation (Fig. 1).—(1) Branches of the external carotid on the side tied, anastomosing with the corresponding branches of the opposite side (4), viz. (*a*) Facial with facial. (*b*) Temporal with temporal. (*c*) Occipital with occipital. (*d*) Superior thyroid with superior thyroid. (2) Anastomoses between the internal carotids of opposite sides through the anterior segment

of the 'circle of Willis'—anterior cerebral of the one side, with the anterior cerebral of the other, through the anterior communicating (1). (3) Anastomoses between the subclavian and external carotid of the side tied—(*a*) Deep cervical (11), with princeps cervicis of occipital (6). (*b*) The vertebral (8) with the occipital (7). (*c*) Inferior thyroid, with superior thyroid (10). (4) Anastomoses between the subclavian and the internal carotid of the side tied, the vertebral (from subclavian) through the basilar and posterior cerebral, with posterior communicating from internal carotid, *i.e.*, through the lateral segment of the 'circle of Willis' (1). (5) Anastomoses of the ophthalmic, from the internal carotid, through the 'circle of Willis,' with branches of the external carotid on the side tied. (*a*) Nasal of ophthalmic, with angular of facial. (*b*) Infraorbital from internal maxillary, with twigs of facial. (*c*) Supraorbital and frontal from ophthalmic, with terminations of the anterior temporal.

The most common cause of death after ligature of the common carotid is cerebral disease induced by the operation, from the sudden interference with the cerebral circulation; the symptoms are twitchings, tremblings, convulsions, syncope, giddiness, and sometimes complete hemiplegia, probably due to the diminished supply of arterial blood. In other cases drowsiness, stupor, and apoplexy supervene, probably from the venous congestion. Besides the cerebral symptoms the lungs, in many cases, appear to be affected, probably from the interference with the blood supply to the medulla oblongata, they become congested and are apt to run into a low form of inflammation, just as in injury to the vagi.

INTERNAL CAROTID ARTERY.

Origin.—From the bifurcation of the common carotid opposite the upper border of the thyroid cartilage. It is deeper and further from the middle line (*i.e.* more posterior) than the external. **Course.**—Its course is indicated by the same line that marks the course of the common carotid. The part below the posterior belly of the digastric (*i.e.* the part in the carotid triangle) is the only accessible portion. **Relations.**—In **front**—(1) Skin; (2) superficial fascia; (3) platysma; (4) deep fascia; (5) crossed by the ninth nerve sending down descendens noni; (6) also, crossed by the occipital artery giving off some sterno-mastoid branches. Higher up we find (7) the parotid gland; (8) stylo-glossus and stylo-pharyngeus muscles; (9) glosso-pharyngeal nerve and pharyngeal branch of vagus; (10) external carotid artery. On the **outer** side—(1) Internal jugular vein; (2) spinal accessory nerve. On the **inner** side—(1) Pharnyx; (2) ascending pharyngeal artery; (3) pneumo-gastric nerve. **Behind**—(1) Gangliated cord of sympathetic; (2) superior laryngeal nerve (internal and external branches): (3) rectus capitis anticus major; (4) further back the cervical vertebræ.

Incision.—With the patient in the same position as in ligature of the common carotid, an incision should be made in the line of the vessel along the inner edge of the sterno-mastoid muscle from the angle of the jaw to the upper border of the thyroid cartilage. The best position for applying the ligature is about midway between the hyoid bone and the digastric. By this incision we cut through (1) skin: (2) superficial fascia;

(3) platysma; (4) deep fascia. Draw aside the sterno-mastoid, when, (5) the occipital artery, with its mastoid branch, and, (6) the ninth nerve, with its descendens noni branch, are brought into view. Turn these aside, open the sheath, clear the vessel, and pass the ligature. Great care is necessary in clearing the vessel on account of its close relation to the internal jugular vein on its outer side, the vagus nerve behind and to its inner side, and the external carotid above and somewhat to its inner side. The needle is to be passed from the outer side, *i.e. from* the vein.

This is an operation rarely if ever performed on the living body. In cases of wound of the vessel in the neck by a stab or bullet, &c., it should, if possible, be tied at the bleeding point, but in this case the wound is the guide. In cases of intra-cranial and orbital aneurism ligature of the common carotid is the more effectual operation. Should it be wounded from the fauces ligature of the common trunk is the proper plan of treatment. **Note.**—The vessel lies at this part of its course, external to the external carotid. The internal jugular vein is to its outer side, and, therefore, the aneurism needle should be passed *from* this side; further, the gangliated cord of the sympathetic and the vagus, with its superior laryngeal branch is behind it. When one internal carotid trunk has been tied the circulation is very speedily re-established by the internal carotid, and vertebral of the opposite side, and vertebral of the same side, through the 'Circle of Willis.'

PECULIARITIES.—The length of the internal carotid varies according to the point of bifurcation of the common. Sometimes it springs directly from the arch of the aorta: occasionally it is altogether absent.

EXTERNAL CAROTID ARTERY.

Origin.—At the same point as the internal. **Extent.**—From its point of origin upwards to a point opposite the neck of the condyle of the lower jaw, where it divides into temporal and internal maxillary arteries. In the child it is smaller than the internal, but in the adult the two vessels are almost of equal size. **Course.**—Runs upwards and slightly outwards, passing between the angle of the jaw and the mastoid process, lying a little to the front of the anterior border of the sterno-mastoid, very nearly corresponding to a line drawn from the front of the meatus of the ear to the cricoid cartilage, slightly arched forwards.

Relations.—In the *first* part of its course the vessel lies in the carotid triangle, and is quite superficial, being merely covered by (1) skin; (2) superficial fascia; (3) platysma, with branches of the superficial cervical, great auricular, and infra-maxillary branches of the facial nerve; (4) deep fascia; (5) lingual and facial veins, and may be slightly overlapped by the sterno-mastoid. In the *second* part of its course it is deeper, being covered by (6) the posterior belly of the digastric and stylo-hyoid muscles, and (7) crossed by the ninth nerve. In the *third* part it is still deeper, for it passes beneath the deep surface and enters the substance of (8) the parotid gland and the structures in its substance. Behind the vessel we have (1) the superior laryngeal nerve with its external branch and the structures which separate the external from the internal carotids, viz., (2) stylo-pharyngeus and (3) stylo-glossus muscles; (4) styloid process, if long (if short

we will have the stylo-hyoid ligament); (5) glosso-pharyngeal nerve, and (6) pharyngeal branch of vagus.

It may be ligatured as it lies in the carotid triangle, but its branches are so numerous that its ligature is apt to be followed by secondary hæmorrhage. The best point for the application of the ligature is between the origins of the superior thyroid and lingual arteries. The patient is to be placed in the same position as in ligature of the common carotid. At this part of its course it is covered by a large plexus of veins, formed by the lingual, facial, and pharyngeal veins, with communications from the superior thyroid and external jugular. The incision used in ligature of the internal carotid will also do for ligature of this vessel, or the incision may be half an inch nearer the middle line of the neck, and should extend from near the angle of the jaw to the level of the thyroid cartilage. Carefully cut through the structures covering it in the first part of its course. Turn the large veins to one side if possible, or else tie them with a double ligature and cut between. The sterno-mastoid must be pulled backwards, the digastric and stylo-hyoid muscles with the hypoglossal nerve forwards and upwards, and the parotid gland upwards. The descendens noni is external to and somewhat behind the vessel, and is not likely to be wounded, but the thyro-hyoid branch is immediately in front, and if seen should be hooked aside. The vessel is then to be cleared, and the needle passed from the outer side, and in doing so care should be taken to avoid injuring or including the descendens noni, superior laryngeal nerve, or ascending pharyngeal artery.

The external carotid may be ligatured for wounds of

the main trunk or its branches, various forms of aneurism of the face and scalp, &c. In cases of wounds, or aneurism the result of a wound, the vessel or its branches should be secured at the injured point. In cases of idiopathic aneurism and pulsating tumours of scalp, ligature of the common carotid is the more effectual operation on account of the large number of branches given off by the external.

Collateral Circulation (Fig. 1).—(1) Branches of the external carotid on the side tied anastomosing with the corresponding branches of the opposite side (4), viz. (*a*) facial with facial; (*b*) temporal with temporal; (*c*) occipital with occipital; (*d*) superior thyroid with superior thyroid (10). (2) Anastomoses between the subclavian and the external carotid of the side tied (*a*) deep cervical (11) from the superior intercostal, with the princeps cervicis (6) of the occipital; (*b*) the vertebral with the occipital in the region of the sub-occipital triangle (7); (*c*) inferior thyroid with the superior thyroid (10). (3) Nasal of the ophthalmic anastomosing with the angular of the facial.

THE PULSE IN ANEURISM of the aorta and vessels at the root of the neck.—According to Dr Mahomed the chief characters of the aneurismal pulse recognisable by the **finger** are—(1) Delay; (2) diminution in volume; (3) diminution in force; (4) persistency; (5) in some cases a thrill may be felt. In many cases the finger can perceive a want of parallelism in the beats of the radials; but in many cases the differences are too slight to be detected by the finger. The characters of a **sphygmographic** tracing are—(1) A sloping upstroke, due to the delay of the pulse wave; (2) diminished volume of wave; (3) impairment of

percussion, from the diminution in the force of the wave; (4) obliteration of secondary waves; (5) inequality of the pressure employed on the two sides; (6) sometimes vibratile waves, corresponding to the thrill sometimes felt by the finger. A constant dissimilarity in the pulse tracings of the two radials is the most valuable sign, and this is best of all demonstrated by sphygmographic tracings.

The presence of the signs above enumerated in the pulse at both wrists would indicate an aneurism of the ascending arch; if the right pulse be affected more than the left, the aneurism must involve the innominate; if the left more than the right the aneurism is of the transverse arch beyond the innominate.

CHAPTER VIII.

BRANCHES OF THE EXTERNAL CAROTID.

An Anterior Set.—(1) Superior thyroid; (2) lingual; (3) facial. **A Posterior Set.**—(1) Occipital; (2) posterior auricular; (3) sterno-mastoid (sometimes). **An Ascending Set.**—(1) Temporal; (2) internal maxillary; (3) ascending pharyngeal. The sterno-mastoid branch has three possible modes of origin (1) From the external carotid; (2) from the occipital; (3) from the superior thyroid.

Thyroid Arteries.—Ligature of these arteries has been practised by some surgeons as a cure for bronchocele, with but doubtful success. We have already referred to ligature of the **inferior thyroid** (see p. 62).

The Superior Thyroid.—This vessel is a branch of the external carotid. It is the lowest of the three branches arising from the anterior surface of that vessel, and is usually given off not far from its origin, as it lies in the carotid triangle. The superior thyroid itself, therefore, is at first merely covered by the common investments of the parts, and at this point it may be ligatured. Make an **incision** three inches long parallel with the anterior edge of the sterno-mastoid but half an inch nearer the middle line, so that it shall lie over the external carotid artery, the centre of the incision being opposite the superior cornu of the

thyroid cartilage (the artery usually arises somewhat below the great cornu of the hyoid bone). Here the vessel passing upwards and inwards is quite superficial, being covered only by skin, superficial fascia, platysma, and deep fascia, and may be readily tied. After this it takes an arched course downwards, passing beneath the omo-hyoid, sterno-hyoid, and sterno-thyroid muscles to the upper part of the thyroid body.

Branches.—(1) Hyoid branch, runs inwards *below* the hyoid bone; (2) sterno-mastoid, passes outwards across the carotid sheath to the sterno-mastoid muscle; it is important to note the relation of this little branch to the carotid sheath, as it is in the way in the operation of tying the common carotid above the omo-hyoid. (3) Superior laryngeal, pierces the thyro-hyoid membrane and supplies the mucous membrane of the larynx; (4) crico-thyroid, runs across the crico-thyroid membrane. This little branch should be remembered in the operation of laryngotomy, although from its small size it seldom gives rise to any trouble. Occasionally, however, it is of large size; I have seen it as large as an ordinary radial. (5) Terminal branches to the thyroid body.

THE LINGUAL ARTERY.

It may be necessary to ligature this vessel to restrain profuse hæmorrhage from the tongue, *e.g.* in cancerous ulcers, or for the purpose of starving such growths, or preliminary to excision of the tongue. **Origin.**—From the anterior border of the external carotid, either above or below the level of the hyoid bone. **Extent.**—From its origin to the anterior border of the hyoglossus. **Course.**—At first inwards above the hyoid

bone, and then upwards and inwards beneath the hyo-glossus.

Relations.—In the *first* part of its course—from its origin to the posterior border of the hyo-glossus—it passes obliquely upwards and inwards to the great cornu of the hyoid bone, and is quite superficial, being simply covered by the skin, fascia, and platysma, and rests on the middle constrictor of the pharynx. In the *second* part of its course, that beneath the hyo-glossus, it runs forwards parallel with the great cornu of the hyoid bone for a little way, and then ascends to the under surface of the tongue. Here it is covered by the skin, fascia and platysma, crossed by the posterior belly of the digastric and the stylo-hyoid muscle, and sometimes also by the 9th nerve (*Hypoglossal*, formerly known as the *Lingual*) near the posterior border of the hyo-glossus, and lastly it is covered by the hyo-glossus muscle itself. In its second part it rests on the middle constrictor and the genio-hyoglossus muscle. Properly speaking the vessels ends, as such, at the anterior border of the hyo-glossus, and its continuation, the ranine artery, runs forwards to the tip of the tongue to end at the side of the frænum linguæ. In performing this operation the patient's shoulders should be slightly raised, the head thrown well back over a small pillow, and the face turned towards the opposite shoulder. The most trustworthy superficial guide to the vessel is the great cornu of the hyoid bone.

Incisions.—(*A*) In the first form an incision is made downwards and backwards for two or three inches over the great cornu of the hyoid bone, which should correspond to the centre of the incision. Cut through the superficial structures already enumerated, and look

for the **deep guide**, the 9th nerve, which is usually accompanied by a branch of the lingual vein. The artery is deeper than the nerve as it has to pass under the hyoglossus, while the nerve passes over that muscle. The 9th nerve with the posterior belly of the digastric and stylo-hyoid muscles must be displaced upwards, and the external carotid artery backwards by means of blunt hooks, and then, with the great cornu of the hyoid bone in view, search for the vessel in the loose cellular tissue. At first sight it might seem an easy operation to secure the vessel at this part of its course where it is so superficial, but this is by no means the case. There are **two reasons** for this—(1) Because behind the vessel is the soft mobile wall of the pharynx, and, for this reason, it is impossibe to get the artery fixed, and in clearing the vessel great care is necessary lest the wall of the pharynx be wounded. (2) Over the vessel in this region is a large plexus of veins, formed chiefly by the lingual and facial (on their way to empty into the internal jugular) with communications from the superior thyroid and external jugular veins. For these reasons the next form of incision is the one usually adopted, except in cases where the operation is performed preliminary to excision of the tongue, when it is necessary to tie the vessel in this situation, as close to the parent trunk as possible, in order to be sure that, in removing the tongue, the artery will not be cut between the parent trunk and the ligature.

(*B*) In the **second form** of incision the vessel is tied as it lies beneath the hyoglossus at the apex of the digastric triangle. This is the French method, and is the one recommended by Mr C. Heath. A curved **incision** is made from a point a little below and behind

the symphysis menti down to the level of the hyoid bone, and then turning upwards till it nearly reaches the angle of the jaw. It must not be carried quite up to the angle of the jaw lest the facial vein be injured. After dividing the superficial structures the submaxillary gland is exposed, and must be displaced upwards with a blunt hook. Then the boundaries of the triangle in which the vessel lies are to be recognised, viz., the two bellies and the intervening tendon of the digastric on each side, and the 9th nerve above; the nerve is to be dissected up a little and held aside, when the hyo-glossus muscle is then exposed. The fibres of the muscle are to be divided transversely about a couple of lines above the hyoid bone, the vessel carefully cleaned, and the needle passed from above downwards. In the dead body the muscle seems thinner than one might expect, and, unless care be taken, the operator may easily open into the pharynx. Some operators use an incision an inch and a quarter in length, parallel with, and one-third of an inch above, the great cornu of the hyoid bone.

PECULIARITIES.—The lingual artery sometimes arises from a trunk common to it and the facial; less frequently it is joined with the superior thyroid.

Branches.—(1) Hyoid, which runs along the upper border of the hyoid bone. (2) Dorsalis linguæ, which arises and ascends beneath the hyo-glossus to the dorsum of tongue. (3) Sublingual branches to sublingual gland. (4) Ranine, the direct continuation of the lingual, which runs forwards to the tip of the tongue, and ends in the frænum linguæ. To avoid this little vessel, in relieving the condition known as 'tongue-tie,' the prominent tight *edge* only of the

frænum is nicked by the scissors, and as close to the jaw as possible, any further freeing must be done with the thumb or finger nail.

FACIAL ARTERY.

The first of the incisions for ligature of the lingual would also expose the origin of the facial. It arises from the external carotid artery, a little above the lingual, lying at first in the carotid triangle, where it is simply covered by the superficial investments of the parts (skin, platysma, and fasciæ). It is then crossed by the posterior belly of the digastric and stylo-hyoid muscles and 9th nerve. After this it passes through a groove in the posterior and upper border of the sub-maxillary gland, where it makes a sigmoid flexure, crosses the lower jaw lying on the bone in a little hollow just about the point where the body joins the ramus, in front of the masseter muscle, and only covered by the skin fascia and platysma. Here its pulsations can be felt during life, and it may be readily compressed with the finger or ligatured by an incision one inch in length parallel with the fibres of the muscle. After this, its general direction is towards the angle of the mouth, angle of the nose and inner angle of the eye, but in a very tortuous course. In its course through the face it is covered by the superficial structures and platysma, and that special part of the platysma known as the risorius muscle: it is also covered by the zygomatic muscles, and crossed by branches of the facial nerve. It rests on (1) the lower jaw, (2) buccinator, (3) levator anguli oris, (4) levator labii superioris.

PECULIARITIES.—The facial artery may arise by a

common trunk with the lingual. Sometimes it terminates as the submental, and in other cases may only supply the face as high as the angle of the mouth or nose.

Branches.—In neck.—(1) Inferior or ascending palatine, which passes upwards between the stylo-glossus, and the stylo-pharyngeus muscles supplying them, the tonsil and the Eustachian tube, and sends a branch through the space of Morgagni to the soft palate. (2) Tonsillar, which perforate the superior constrictor to reach the tonsils. (3) Glandular to sub-maxillary gland. (4) Sub-mental, given off immediately below the lower jaw to the chin. This is the largest branch and must be kept in mind in operations about the lower jaw, such as excision, &c.; it runs forwards on the mylo-hyoid muscle. On the face.—(1) Inferior labial, which passes beneath the depressor anguli oris to supply the lower lip and chin. (2) The two coronary arteries which pass along the free margin of each lip. They are covered by the depressor anguli oris and then perforate the orbicularis oris and run in a tortuous course between this muscle and the mucous membrane. The superior is the larger, and gives off the artery to the septum. In operations about the lips, therefore, these must be kept in mind; (3) lateral nasal to side of nose; (4) angular, its terminal branch, anastomosing at the inner angle of the orbit with the nasal branch of the ophthalmic; and this is one reason why leeches at the inner angle of the eye relieve congestion of the eye or brain. It also anastomoses with the infra-orbital branch of the internal maxillary in the same region.

OCCIPITAL ARTERY.

This vessel arises from the posterior surface of the external carotid just as that vessel is about to pass beneath the posterior belly of the digastric. It may be divided into three parts—(1) a part that passes upwards and backwards almost parallel with and partially overlapped by the posterior belly of the digastric and stylo-hyoid, to a point between the transverse process of the atlas and mastoid process of the temporal bone. This part is usually quite superficial at first, being simply covered by the integument; afterwards it is overlapped by the muscles already mentioned, and part of the parotid gland. It, however, *crosses* the following important structures—(*a*) internal carotid artery; (*b*) vagus; (*c*) internal jugular vein; (*d*) spinal accessory nerve; (*e*) 9th nerve (hypoglossal) which hooks round it; (*f*) gangliated cord of the sympathetic. (2) A part passing backwards and inwards along the superior curved line. At this part of its course it *lies* on—(*a*) rectus lateralis; (*b*) superior oblique; and (*c*) complexus; and is *covered* by—(*a*) trapezius; (*b*) sterno-cleido-mastoid; (*c*) splenius capitis; (*d*) digastric; (*e*) trachelo-mastoid; and is overlapped by (*f*) the mastoid process. (3) The third part pierces the trapezius and turns upwards to the scalp; this part is accompanied by the great occipital nerve and a cutaneous twig from the suboccipital as well.

PECULIARITIES.—The occipital artery is sometimes derived from the internal carotid, or from the ascending cervical branch of the inferior thyroid.

Branches.—(1) A sterno-mastoid branch; (2) auri-

cular, to concha; (3) meningeal, which enters the skull through the jugular foramen; (4) princeps cervicis. This vessel passes downwards and divides into a superficial and deep part. The *superficial* part runs beneath the splenius, lying on the complexus; the deep branch lies between the complexus and the semi-spinalis colli, and anastomoses with the vertebral and the profunda cervicis branch of the superior intercostal artery in the region of the suboccipital triangle. This anastomoses forms an important collateral supply in the ligature of the common carotid or subclavian artery. (5) Occipital to scalp, which anastomose with the corresponding branches from the opposite side, and with the temporal arteries.

Posterior Auricular.—This branch is given off above the digastric and stylo-hyoid muscles runs along the upper border of the digastric, and passes between the facial and spinal accessory nerves. It anastomoses with the occipital and temporal arteries. Its **branches** are—(1) the *stylo-mastoid*, which enters the stylo-mastoid foramen and supplies the middle ear, mastoid cells, and semicircular canals; (2) the *auricular*, which is distributed to the back of the cartilage of the ear.

Ascending Pharyngeal.—This branch arises near the commencement of the external carotid, and ascends by the side of the pharynx, and to the inner side of the internal carotid, to the base of the skull, beneath the other branches of the external carotid and the stylo-pharyngeus muscle, but lying on the rectus capitis anticus major. Its **branches** are distributed to the muscles in this region, to the dura mater and to the pharynx. The branches to the dura mater (*meningeal*) pass through the foramen lacerum medius, foramen

lacerum posticus, and sometimes through the anterior condyloid foramen. The *pharyngeal* branches pass through the space of Morgagni to supply the soft palate and anastomose with the ascending palatine of the facial.

Temporal Artery.—This is one of the terminal branches of the external carotid. It arises in the parotid gland on a level with the neck of the condyle of the lower jaw, and passes upwards over the root of the zygoma in front of the ear to the scalp, and divides, about two inches above the zygoma into anterior and posterior branches, which pass in directions indicated by their names. As it crosses the root of zygoma it is covered (1) by a dense fascia derived from the parotid gland (2) several veins; it is also accompanied in this region by branches of the facial and the auriculo-temporal nerves. It is on account of these relations that the operation of arteriotomy should not be performed in this situation, as the dense fascia interferes with the free flow of blood during the operation, as well as causing some difficulty in controlling the hæmorrhage afterwards. Further, one of the veins might be wounded in the operation and subsequently give rise to varicose aneurism or aneurismal varix, or severe neuralgia might result from injury to the auriculo-temporal nerve. For the purpose of arteriotomy the anterior temporal is the branch usually selected. **Branches.**—(1) *Anterior temporal:* (2) *posterior temporal:* (3) *transverse facial*, given off in the substance of the parotid gland, and runs forwards over the masseter muscle, just below the zygoma but above Stenson's duct, and anastomoses with the infra-orbital and facial. (4) *Middle temporal*, which pierces the

temporal fascia and supplies the temporal muscle. This vessel sometimes gives off an *orbital* branch, which runs along the upper border of the zygoma between the two layers of the temporal fascia to the outer angle of the orbit. (5) *Anterior auricular*, to the anterior part of pinna, the lobule, and part of the external auditory meatus.

THE INTERNAL MAXILLARY ARTERY.

This vessel has, so far as I am aware, but little direct surgical interest. Its branches, however, are involved in many important surgical operations, such as excision of the upper and lower jaws, hæmorrhage after the removal of teeth, &c.; and its middle meningeal branch may be injured in fracture of the temporal region of the skull. The middle meningeal enters the skull through the foramen spinosum of the sphenoid bone, and divides into two branches, an anterior and a posterior; it is the anterior branch that possesses the greatest interest from a surgical point of view. From the foramen spinosum it crosses the great wing of the sphenoid, and then enters a canal or groove in the anterior inferior angle of the parietal bone. At this part of its course its position may be indicated on the surface by taking a point an inch and a half behind the external angular process of the frontal bone, and an inch and three-quarters above the zygoma. After this the anterior branch passes upwards and slightly backwards to the upper margin of the parietal bone, from half an inch to an inch behind the coronal suture. This point is easily indicated on the surface, since the coronal suture is as nearly as possible five inches from the root of the nose, and the artery is

therefore half an inch to an inch behind this. The posterior branch of the artery passes upwards and backwards over the squamous portion of the temporal bone.

Should it be necessary to trephine for the relief of hæmorrhage in fracture of the skull in this region, define the position of the anterior branch of the artery in the manner already indicated, and at this point make a ⊥-shaped incision, the horizontal limb of which is parallel with and about an inch above the zygoma, the vertical limb passing upwards as far as necessary. Turn back all the structures right down to and including the pericranium, search for the line of fracture and apply the trephine. Should there be no fracture visible, even though the symptoms (signs of compression coming on, not immediately after the injury but after an interval of consciousness—paralysis of the opposite side of the body and face) point to extravasation of blood, then trephine over the course of the vessel. The structures divided in this operation are (1) skin, (2) superficial fascia, and closely connected with it the superficial temporal vessels and auriculo-temporal and temporo-malar nerves, and a thin fascia prolonged from the central tendon of the occipito-frontalis, with the attolens and attrahens muscles arising from it. (3) The two layers of the temporal fascia and between them the orbital artery, and a twig of the orbital branch of the superior maxillary nerve with its artery, and some fatty tissue; (4) the temporal muscle with the middle temporal artery; (5) the deep temporal vessels; (6) pericranium; (7) bone, which at this point is thin and contains but little diploë. The circle of bone will probably include portions of the frontal, parietal, sphenoid, and squamous part of the temporal.

CHAPTER IX.

AXILLARY ARTERY.

Origin.—It is the direct continuation of the subclavian. **Extent.**—From the lower border of the first rib, to the lower border of the insertion of the teres major. **Course.**—With the arm well abducted, its course is indicated by a line drawn from a point somewhat to the sternal side of the middle of the clavicle, to the inner border of the coraco-brachialis muscle. It is divided into three parts—a part above, a part beneath, and a part below the pectoralis minor.

The First Part.—This part extends from the lower border of the first rib to the upper border of the pectoralis minor. **Position of the Arm.**—The shoulder should be pushed up and lie free with a pillow under it; the elbow at first is to be drawn slightly away from the body, and the head inclined to the opposite side. When the superficial structures and the pectoralis major are divided then the arm must be brought close to the side to relax the pectorals and allow them to be displaced downwards by an assistant. With the arm in this position the **operator** standing between the arm and the chest makes an **incision** parallel with the clavicle or with a slight convexity downwards from a point half an inch external to the sterno-clavicular articulation, to a point half an inch internal to the

coracoid process. It is better not to go quite up to the coracoid process in order to avoid cutting the cephalic vein as it lies in the groove between the pectoralis major and the deltoid. We cut through—(1) Skin; (2) superficial fascia; (3) platysma; (4) deep fascia; (5) clavicular head of the pectoralis major which must be divided across its fibres, taking care to avoid the *cephalic vein*, which is seen at the outer angle of the incision in the groove between it and the deltoid. After this we meet with a quantity of fatty tissue, in which ramify, or pass through, the structures that pierce the costo-coracoid membrane, viz:—(*a*) Cephalic vein; (*b*) external anterior thoracic nerve; (*c*) thoracic axis, or acromio-thoracic artery; (*d*) superior thoracic artery; (*e*) corresponding veins. The arm having been brought to the side and the upper edge of the pectoralis minor muscle exposed and displaced downwards by a broad copper spatula and any large arterial branch pulled inwards by a blunt hook, pass carefully through the fatty tissue, cutting as little as possible, lest the above structures be injured, till the axillary sheath (part of the costo-coracoid membrane) is exposed. (6) Open this sheath, taking care not to wound the axillary vein, which is superficial and internal to the artery. The cords formed by the union of the spinal nerves entering into the formation of the brachial plexus, lie to its outer side, or partially overlapping it. Clear the artery with a director, and pass the needle *from* the vein and above the origin of the thoracic axis. At this part of the axillary, the artery, vein, and nerve, all lie obliquely to each other—the vein overlapping the artery, and the artery overlapping the nerve. This is the position of the various structures when the arm is hanging by the

side, but when it is abducted to any extent the vein is almost right in front of the artery. Take care not to include the anterior thoracic nerve.

Behind this part of the vessel is the first digitation of the serratus magnus, and the posterior thoracic nerve (nerve of Bell). Ligature of this part of the axillary artery is a dangerous operation, because of—(1) Its great depth; (2) its relation to other blood vessels, *e.g.*, the axillary and cephalic veins, and branches of the thoracic axis; (3) Its relation to nerves, *e.g.*, the external anterior thoracic in front, and the posterior thoracic behind.

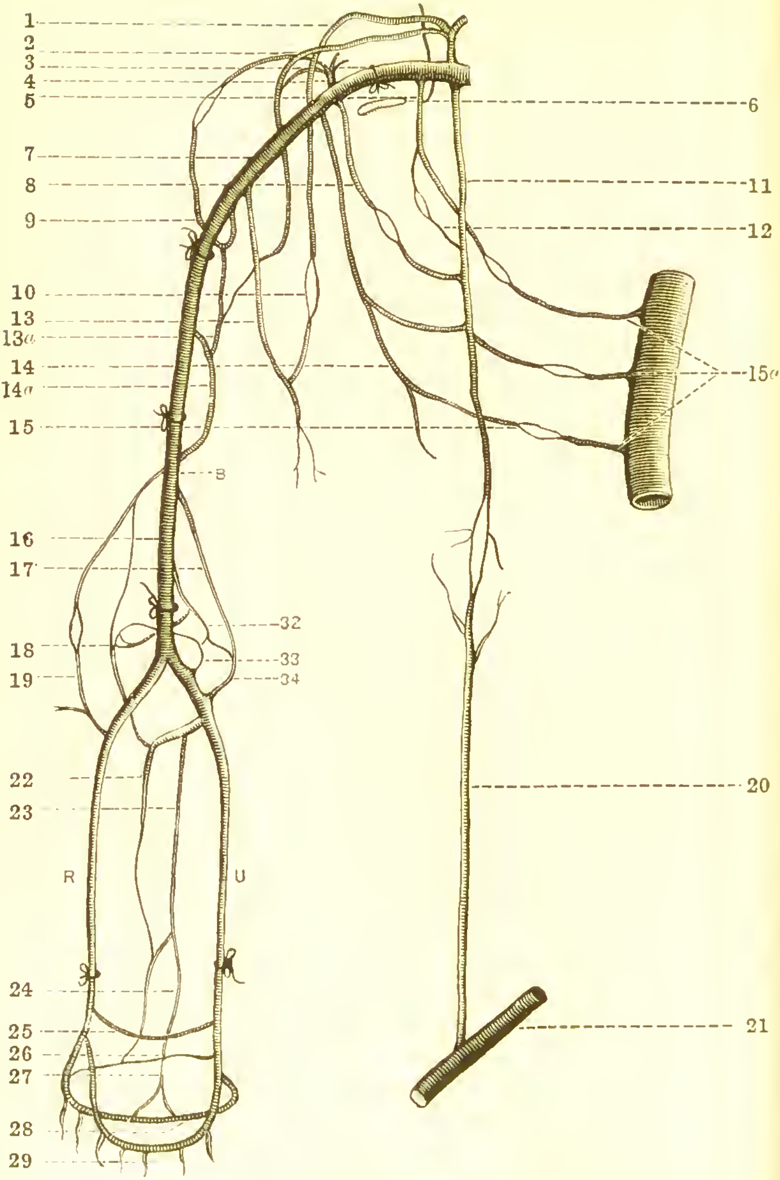
Collateral Circulation (Fig. 3).—If tied **above** the thoracic axis it is the same as in ligature of the third part of the subclavian. If tied **below** the axis, in addition to the chief collateral branches mentioned under 'collateral circulation' (see p. 59) in ligature of the subclavian, we have—(*a*) Branches from the thoracic axis (4), and superior thoracic (8), anastomosing with branches from the two circumflex arteries (9) (third part of the axillary; (*b*) the long thoracic (14) anastomosing with the aortic intercostals (15*a*) and internal mammary (11).

The Second Part.—The part beneath the pectoralis minor is not tied except when wounded—(1) Because it is short and gives off two or three branches; (2) it is too deeply placed; (3) it is so closely surrounded by nerve trunks. It is covered by the two pectoral muscles, and the three cords of the brachial plexus are arranged, one on each side, and one behind it.

The Third Part.—This is the longest of the three parts, and extends from the lower border of the pectoralis minor to the lower border of the teres

[*To follow page 94.*

Fig. 3.



COLLATERAL CIRCULATION OF THE UPPER EXTREMITY
(After SMITH and WALSHAM).

Explanation of Fig. 3.

1. Posterior scapular artery. 2. Suprascapular artery. 3. Subclavian artery. 4. Thoracic axis. 5. Superior intercostal artery. 6. The first rib. 7. Axillary artery. 8. Superior thoracic branch. 9. Posterior circumflex artery, anastomosing with the thoracic axis. 10. Anastomosis between the posterior scapular and the dorsalis scapulæ. 11. The internal mammary. 12. Anastomosis between the internal mammary and the superior intercostal. 13. Subscapular artery. 13*a*. Anastomosis between the superior profunda and the posterior circumflex. 14. Long thoracic. 14*a*. The superior profunda. 15. Anastomoses between the long thoracic, internal mammary, and aortic intercostals. 15*a*. Aortic intercostals. 16. Brachial artery. 17. Inferior profunda. 18. Interosseous recurrent. 19. Radial recurrent. 20. Deep epigastric. 21. External iliac. 22. The posterior interosseous. 23. Anterior interosseous. 24. Terminal branches of the anterior interosseous. 25. Anterior carpal arch. 26. Posterior carpal arch. 27. Recurrent branches. 28. Deep palmar arch. 29. Superficial palmar arch. 32. Anastomotic branch. 33. Anterior ulnar recurrent. 34. Posterior ulnar recurrent.

major: it is twice as long as either of the others. **Position of the Arm.**—The arm is abducted to a right angle with the trunk by an assistant, and at the same time fully supinated; the **operator** stands between the arm and the trunk on both sides of the body.

Superficial Guide.—The prominence caused by the coraco-brachialis, or divide the base of the axilla into thirds, when the artery will be found to lie at the junction of the anterior with the middle third. Make an **incision** along the inner side of this muscle and parallel with the anterior fold of the axilla for about three inches into the hollow of the armpit. **Cut through**—(1) Skin; (2) fascia, avoiding the basilic vein should it be in the way, and expose the edge of the coraco-brachialis. After dividing the fascia (superficial and deep) the median and the internal cutaneous nerves, with the artery behind and between them will be seen, or more correctly, the artery is really surrounded by nerve trunks; to the outer side are the median and the musculo-cutaneous nerves; on the inner side the ulnar and nerve of Wrisberg; above, the internal cutaneous; behind, the musculo-spiral and circumflex. The axillary vein lies to its inner side. These branches form the **Deep Guide**, and in the midst of them the artery will usually be found. Relax the arm by bending it, and by means of blunt hooks displace the median nerve to the outer side, the axillary vein with the ulnar and internal cutaneous nerves, and the basilic vein, if present, to the inner side. Carefully expose and open the sheath, clear the artery with a director, and pass the needle from the inner side, taking care not to include the musculo-spiral or circumflex nerves which lie behind the vessel. To give, shortly, the entire

relations of the artery—In front—(1) Integument and fascia, and this only at the lower part of its course; (2) Pectoralis major (at the upper part), and internal cutaneous nerve; (3) Inner head of median. Behind—(1) Subscapularis; (2) Tendons of latissimus dorsi and teres major; (3) Musculo-spiral and circumflex nerves. On the outer side—(1) Coraco-brachialis; (2) median nerve; (3) musculo-cutaneous nerve. On the inner side—(1) Ulnar nerve; (2) nerve of Wrisberg; (3) axillary vein. The median nerve has a triple relation to this part of the artery—(1) Its two heads embrace it; (2) it usually lies above it; (3) it is placed to its outer side. This part of the axillary artery is better fitted for ligature than the parts we have previously considered—(1) It is twice as long as either of the others; (2) its lower part (half or third) is simply covered by the common tegumentary structures, and has no muscle above it; (3) its branches come off well up towards its beginning, and are therefore well out of the way at the point where the artery is usually ligatured. This is important, because if the vessel is ligatured too near these branches secondary hæmorrhage is apt to occur. Therefore the ligature should be applied as low down as possible.

PECULIARITIES.—(1) The artery may be covered by a muscular slip from the latissimus dorsi; (2) in one out of every ten cases there are two arteries instead of one, the second usually being one of the arteries of the forearm, usually the radial, sometimes the ulnar, and still more rarely the interosseous. In other cases the circumflex, subscapular, and profunda arteries arise from the third part by a common trunk. (3) The position of the nerves vary; instead of encircling the

axillary artery, they may encircle a large branch formed by the union of several of the usual branches, and in this case they would therefore be useless as the 'deep guide.'

Collateral Circulation (Fig. 3).—If tied above the subscapular branch, it is the same as when the first part is ligatured. If tied below this branch, the collateral anastomoses are small, but usually sufficient—(*a*) anastomoses between branches of the posterior circumflex (9) and the superior profunda (14*a*); (*b*) anastomoses between branches of the subscapular (13) and the superior profunda (14*a*); (*c*) anastomoses through the coraco-brachialis, biceps, and long head of the triceps—muscular branches; (*d*) through the shaft of the humerus.

An axillary aneurism presents as a pulsating tumour immediately below the clavicle, under the great pectoral or at the anterior fold of the axilla. There is pain and numbness in the arm and hand from pressure on the brachial plexus, and œdema from pressure on the axillary vein. Special care must be taken not to wound the axillary vein, as air is apt to be sucked in by the aspirating power of the thorax, and also because the fascia in this region is adherent to the vein and prevents its collapse; and for a like reason it bleeds very severely when wounded.

Branches.—**Of the First Part.**—(1) Superior thoracic; (2) acromio-thoracic, or thoracic axis, situated at the *upper* border of the pectoralis minor. **From the Second Part.**—(1) The long thoracic or external mammary, which runs along in the *anterior fold* of the axilla at the *lower* border of the pectoralis minor to the mammary region; (2) alar thoracic. **From the Third Part.**—

(1) Subscapular artery, which runs along in the *posterior fold* of the axilla at the lower border of the subscapularis muscle; (2) posterior circumflex; (3) anterior circumflex. These encircle the surgical neck of the humerus.

BRACHIAL ARTERY.

Origin.—It is the direct continuation of the axillary. **Extent.**—From the lower border of the teres major to a point opposite the neck of the radius—about half-an-inch below the bend of the elbow—where it divides into radial and ulnar arteries. **Course.**—Its course corresponds to a depression along the inner border of the coraco - brachialis and biceps muscles, or a line drawn from the junction of the anterior with the middle third of the base of the axilla to the middle of the bend of the elbow. It is at first to the inner side of the humerus, but gradually turns to the front of that bone; in applying digital compression this relation of the artery to the humerus must be kept in mind, *e.g.*, if it is compressed at the upper part the pressure must be directed from within outwards, if at the lower part from before backwards.

Relations of the Vessel.—In **front**—(1) Skin, superficial and deep fascia; (2) bicipital fascia, with median basilic vein lying on it; (3) Median nerve crossing from the outer to the inner side. Note the triple relation of this nerve to the artery—at the *outer* side, above; in *front*, about the middle; and at its *inner* side, below. **Behind**—(1) Long and inner heads of triceps; (2) Insertion of coraco-brachialis; (3) Brachialis anticus; (4) Musculo-spiral nerve and superior profunda artery lying between it and the long head of triceps.

On the inner side—(1) Median, ulnar, and internal cutaneous nerves; (2) basilic vein. On the outer side—(1) Median nerve; (2) coraco-brachialis; and (3) biceps.

The vessel may be ligatured—(1) In the **upper third** of its course, above the origin of the superior profunda. Here the coraco-brachialis is the **guide**; the median nerve is to its outer side, and the ulnar and internal cutaneous to its inner side. The steps of the operation are precisely similar to ligature of the third part of the axillary, low down. (2) In its **middle third**, below the origin of both the profunda arteries, the point usually selected; the edge of the biceps is the **guide** to the vessel and the median nerve crosses it obliquely. (3) In the **lower third** at the bend of the elbow, and below the origin of all its branches; it lies between the tendon of the biceps on the outer side, and the median nerve on the inner side, and covered by the bicipital fascia and the median basilic vein.

IN THE MIDDLE OF THE ARM.—**Superficial Guide.**—The prominence caused by the inner edge of the biceps. **Position of the Arm.**—It should be held, by an assistant, fully supinated, at right angles to the trunk and not allowed to rest on any support, as this is apt to push up the triceps and displace the vessel (HEATH). The **operator** should stand behind the arm on both sides of the body, but may, if he think it more convenient, stand between the arm and the trunk in both cases. **Incision.**—This should be about three inches long, and made on the biceps (and not exactly over the vessel) parallel with and close to its inner edge, but avoiding the basilic vein. We divide the skin, fatty

tissue, and superficial fascia, and then define the inner edge of the biceps, and draw it aside and cut through the deep fascia, and look for the **deep guide**.—The median nerve close to the edge of the biceps, or crossing the vessel in the bottom of the wound from without inwards. By means of blunt hooks draw the basilic vein and median nerve to the inner side, and the biceps to the outer side (the median nerve may be displaced to the side found most convenient), the assistant who has charge of the arm at the same time bending the elbow to relax that muscle. Separate the sheath from the surrounding structures, open it, clear the vessel with a director, and pass the needle *from* the nerve, at the same time taking care not to injure the venæ comites which often surround the vessel with anastomosing loops. The mobility of the vessel, as well as its relation to the basilic vein and median nerve, makes the operation sometimes a little difficult.

AT THE BEND OF THE ELBOW.—With the **arm** at right angles to the trunk, and the forearm freely supinated, the **operator** standing behind the arm on the right side, but between the arm and the trunk on the left side, ascertains the position of the median basilic vein and the tendon of the biceps, and then makes an **incision** two inches in length, parallel with and a little above the vein. This incision is to the inner side of the tendon of the biceps, and must not be prolonged too far downwards lest the median cephalic vein be cut. Draw aside the median basilic vein and the internal cutaneous nerve by a blunt hook and thus expose the bicipital fascia; divide this on a director, and then the artery is seen lying between the tendon

of the biceps and the median nerve and resting on the brachialis anticus. Bend the elbow and draw the structures on each side away from the vessel, expose and open the sheath, carefully clear the vessel, and pass the needle from the nerve.

Note.—(1) Unless the incision be made close to the inner edge of the biceps, the operator may cut down upon the ulnar nerve with its companion, the inferior profunda artery, and mistake the latter for the brachial. (2) In one out of every five cases there are two arteries instead of one. (3) The biceps muscle has occasionally a third head of origin arising between the coraco-brachialis and the brachialis anticus, and when this is the case it crosses in *front* of the brachial artery near the spot where it is usually ligatured; in other cases a slip may be derived from the coraco-brachialis which crosses the vessel to join the inner head of the triceps. (4) Several cases are recorded where the median nerve passed *under* the artery, instead of over it. (5) The artery, accompanied by the median nerve, sometimes passes to the inner condyle and curves round a prominence of bone, and then passes beneath or through the pronator radii teres to its usual position in front of the bend of the elbow—a condition somewhat similar to the normal condition in many of the carnivora.

Branches.—(1) Muscular; (2) superior profunda which joins and accompanies the musculo-spiral nerve; (3) inferior profunda which accompanies the ulnar nerve; (4) nutrient to humerus; (5) anastomotic branch, which is given off about two inches above the elbow joint, and divides into two branches—one passes to the front of the internal condyle, the other passes behind the joint.

Collateral Circulation (Fig. 3).—This varies according to the point of ligature. At the upper part, in a general way, it is carried on by branches from the circumflex (9) and subscapular (13) arteries, anastomosing with the ascending branches of the superior profunda (13*a*), and muscular branches through the various muscles in the neighbourhood. Ligature above the superior profunda is sometimes followed by gangrene on account of the anastomoses between the axillary and brachial being so scanty. Lower down we have the superior (14*a*) and inferior (17) profundæ above, anastomosing with various branches in the general anastomoses round the elbow joint—*e.g.*, the superior profunda with the radial recurrent (19), posterior interosseous recurrent and anastomotic (18); the inferior profunda (17) with the anterior (33) and posterior (34) ulnar recurrents and anastomotic (32). Besides these there is the circulation through the shaft of the humerus and muscles in the neighbourhood. It will evidently vary therefore according as the vessel is tied between the profunda arteries, below both, or at the bend of the elbow where it is below all the branches.

It will be well, at this point, to give a brief description of the **Anastomoses round the Elbow Joint** (Fig 3). There are seven vessels that take part in this anastomoses—three branches coming down—superior and inferior profundæ and the anastomotic; four branches passing upwards—Radial recurrent, anterior and posterior ulnar recurrents, and the posterior interosseous recurrent. For convenience they may be divided into four groups—(1) In front of **external** condyle, anastomoses between (*a*) superior profunda, and (*b*) radial recurrent (19). (2) In front of **internal** con-

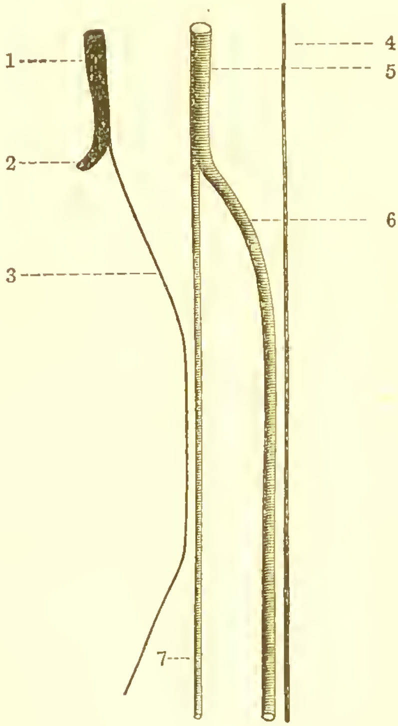
dyle, anastomoses between, (*a*) anastomotic branch (32); (*b*) anterior ulnar recurrent (33); (*c*) inferior profunda (17). (3) Behind external condyle, anastomoses between, (*a*) anastomotic branch; (*b*) interosseous recurrent; (*c*) superior profunda (18). (4) Behind internal condyle, anastomoses between, (*a*) anastomotic branch (32); (*b*) posterior ulnar recurrent (34); (*c*) inferior profunda (17).

RADIAL ARTERY.

This vessel, like the Brachial, of which it is the proper continuation, is quite superficial. **Origin.**—From the bifurcation of the brachial at the bend of the elbow. **Extent.**—From its point of origin till it ends in the deep palmar arch. **Course.**—A line drawn from the centre of the hollow in front of the elbow joint to the inner side of the anterior aspect of the styloid process of the radius will roughly indicate its course. **Relations.**—In front—skin, superficial and deep fascia, cutaneous nerves (especially the external cutaneous which lies over the vessel at the point where the 'pulse' is usually felt) and vessels, &c., and it may be slightly overlapped at the upper part by the supinator longus. On the inner side—(1) Pronator radii teres, above; (2) Flexor carpi radialis, below. On the outer side—(1) Supinator longus; (2) Radial nerve (but only about the middle third of the vessel). Behind—(1) Tendon of biceps; (2) Supinator Brevis; (3) Pronator radii teres; (4) Flexor Sublimis (radial head); (5) Flexor longus pollicis; (6) Pronator quadratus; (7) End of the radius. Note that at the wrist it lies between the tendons of the supinator longus and the flexor carpi

radialis, and that the nerve is only in relation to the *middle third* of its outer side (Fig. 4).

Fig. 4.



RELATION OF ULNAR AND RADIAL ARTERIES AND NERVES.

1. Musculo-spiral nerve. 2. Posterior interosseous nerve 3. Radial nerve. 4. Ulnar nerve. 5. Brachial artery. 6. Ulnar artery. 7. Radial artery.

The vessel may be ligatured—(1) In the upper third of its course, where it lies between the supinator longus and the pronator radii teres, resting on the tendon of the biceps, supinator brevis and part of the insertion of the pronator radii teres. In a muscular arm the supinator longus will overlap the vessel con-

siderably. The radial nerve has no direct relation to this part of the vessel. **Guide.**—The line that indicates the course of the vessel or the inner edge of the supinator longus muscle; find the tendon of this muscle at the wrist, and trace up the muscle towards the bend of the arm. The **arm** should be moderately abducted and the fore-arm fully supinated, and either resting on the table or supported by an assistant: when the muscles are exposed then the assistant may flex the elbow to allow of them being held aside by blunt hooks in the charge of another assistant. The **operator** stands on the outer side of the right arm but on the inner side of the left. **Incision.**—This should be two or three inches in length, and parallel with the inner edge of the muscle. Divide the skin and superficial fascia, define the edge of the supinator longus, and divide the deep fascia parallel with it, draw it a little outwards, and the pronator radii teres inwards and the artery will be seen immediately below this. Separate the venæ comites, clear the artery, and ligature. As the radial nerve has no close relation to this part of the vessel, it matters but little how the needle is passed.

(2) In the **middle third**, where it lies between the supinator longus and the fleshy belly of the flexor carpi radialis, resting on the lower part of the insertion of the pronator radii teres, flexor sublimis and flexor longus pollicis. The radial nerve lies on the outer side of and close to the vessel. The **guide** to the artery and the steps of the operation are almost precisely similar to those of the previous operation. The **incision** need not be quite so long, and, as the nerve lies on the outer side and close to the vessel, the needle should be passed *from* the nerve.

(3) In the **lower third**, where it lies between the tendons of the supinator longus and the flexor carpi radialis, resting on the flexor longus pollicis, pronator quadratus and the end of the radius. The radial nerve has by this time left the artery to pass to the back of the hand, and therefore lies considerably to its outer side. Make an **incision** two inches in length in the middle of the space, bounded by the supinator longus on the outer side, and the flexor carpi radialis on the inner side; at this point the artery may be felt pulsating. Divide the skin, fascia, cutaneous vessels, and nerves (usually one of the terminal branches of the musculo-cutaneous nerve lies over the artery). When the deep fascia is divided, the artery is seen with its venæ comites; avoid these in clearing the vessel and in passing the needle. Complete the operation in the usual manner passing the needle from the side most convenient.

(4) At the **root of the thumb** (in the '*anatomist's snuff box*'). From the anterior aspect of the radius, the artery passes round the root of the thumb to the first interosseous space, where it disappears between the two heads of the first dorsal interosseous muscle; it lies on the external lateral ligament of the wrist joint, scaphoid and trapezium, covered by the skin and fascia, a large vein and filaments of the radial nerve and the three extensors of the thumb—ossis metacarpi, primi internodii and secundi internodii. It is accompanied by its venæ comites and a twig from the musculo-cutaneous nerve. With the hand held by an assistant in a position midway between pronation and supination, the operator makes an **incision** an inch and a half in length from the posterior part of the root of the styloid process of

the radius to the base of the metacarpal bone of the thumb, external to the large vein, and almost parallel with the tendon of the extensor secundi. The first incision divides the superficial structures, but should not injure the vein already mentioned. Divide the deep fascia, hold the tendons aside, when the artery with its venæ comites and a small nerve will be seen crossing the wound obliquely. Separate the venæ comites, and tie the vessel in the usual manner.

PECULIARITIES.—Not infrequently the radial takes its origin from the brachial, sometimes from the axillary. It has been seen more superficial than usual, lying above the deep fascia and the supinator longus muscle.

Branches.—Its branches in the forearm are—(1) The radial recurrent; (2) superficialis volæ; (3) muscular; (4) anterior carpal. At the wrist—(1) Posterior carpal; (2) metacarpal; (3) dorsales pollicis; (4) dorsalis indicis. In the hand—(1) Princeps pollicis; (2) radialis indicis; (3) perforating; (4) interosseous.

Collateral Circulation (Fig. 3).—Chiefly by the ulnar artery and its branches through the palmar arches (28, 29). The anastomoses here are so free, that if the radial is wounded, a ligature must be applied on both sides of the wound.

ULNAR ARTERY.

Origin.—From the bifurcation of the brachial at the bend of the elbow. **Extent.**—From its point of origin till it ends in the superficial palmar arch. **Course.**—It first passes downwards and inwards, and then straight downwards. The course of the straight part may be indicated by a line drawn from the inner condyle of the humerus to the inner side of the pisiform bone.

Relations.—This vessel, unlike the radial, is at first very deeply placed. In **front**—(1) The superficial structures; (2) crossed by the median nerve at its upper part; (3) the following four muscles—(*a*) Pronator radii teres, (*b*) flexor carpi radialis, (*c*) palmaris longus, (*d*) flexor sublimis digitorum. **Behind.**—(1) Brachialis anticus; (2) flexor profundus digitorum. To its **inner** side—(1) Flexor carpi ulnaris; (2) ulnar nerve (for its lower two-thirds). To its **outer** side—the flexor sublimis digitorum. Note.—At the wrist it lies between the tendons of the flexor sublimis digitorum and the flexor carpi ulnaris, and that the nerve is on its inner side for the lower two-thirds (Fig. 4). It may be ligatured at its middle or lower third; the upper third is too deeply situated to admit of ligature except in the case of a direct wound of the artery.

(1) **At its Middle Third.**—**Guide.**—The inter-muscular septum and groove between the fleshy bellies of the flexor carpi ulnaris, and the flexor sublimis digitorum; search for the tendon of the flexor carpi ulnaris and follow it up towards the bend of the elbow and make an **incision** three or four inches in length, parallel with the edge of the flexor carpi ulnaris. We may also use the line that marks the course of the lower two thirds of the artery as our guide. The position of the **arm** is the same as that for ligature of the radial and the **Surgeon** stands on the outer side of the limb, when tying the right ulnar, and on the inner side for the left. Divide the skin and superficial fascia only by the first incision, and then search for the inter-muscular septum between that muscle and the flexor sublimis, and forcibly separate them. At this stage an assistant should flex the wrist to allow of the muscles on each

side being held aside with blunt hooks by another assistant. At the bottom of the wound, the ulnar nerve is exposed, and the artery with its venæ comites on each side will be found to the outer side of the nerve. Pass the needle from the nerve, and complete the operation in the usual manner.

(2) **At its Lower Third.**—Here the artery is quite superficial, and lies between the tendons of the flexor carpi ulnaris and flexor sublimis digitorum. **Superficial Guide.**—Tendon of the flexor carpi ulnaris; the pisiform bone, into which it is inserted, forms a sure guide to the tendon. Or the line that marks the course of the vessel. **Incision.**—Make an incision two inches long parallel with the tendon, but a little external to it. By this incision the skin and superficial fascia are divided; then divide the inter-muscular layer of deep fascia, when the artery and nerve will be exposed to view. The **deep guide** is the ulnar nerve, which lies immediately internal to the artery. Bend the wrist, and draw the tendon of the flexor carpi ulnaris to the inner side, and then isolate the vessel, taking care of its venæ comites and ligature in the usual manner, the needle being passed *from* the nerve, which lies to its inner side.

PECULIARITIES.—The artery not infrequently arises from the brachial, sometimes from the axillary. When its origin is high up it usually passes superficially to the flexor muscles of the forearm, just beneath the deep fascia.

Branches.—The more important branches are—(1) Anterior and (2) posterior ulnar recurrents; (3) Common interosseous, and (4) profunda branch, which is given off just beyond the pisiform bone, and dips down between the abductor minimi digiti and flexor

brevis minimi digiti, and anastomoses, with the radial completing the deep palmar arch. For the termination of the recurrent branches see "Anastomoses round the elbow joint" (p. 102). Other branches are (5) Anterior and (6) posterior carpals, and (7) digital.

Collateral Circulation (Fig. 3).—Chiefly from the radial and its branches through the palmar arches (28, 29.)

PALMAR ARCHES.

(*a*) **Superficial Arch** (Fig. 3, 29).—This is the direct continuation of the ulnar artery. It forms an arch with the convexity downwards, and is completed on the radial side by the *superficialis volæ* branch of the radial artery or, not infrequently by the radialis indicis branch of the same artery. It lies beneath the integumentary structures and palmar fascia, and rests on the digital arteries and nerves, and tendons of the flexor sublimis digitorum. (*b*) **Deep Palmar Arch** (Fig. 3, 28).—This is the direct continuation of the radial artery, and is completed on the ulnar side by the *profunda* branch of the ulnar artery. It lies deeply, and, in addition to the structures covering the superficial arch, it lies beneath the digital nerves and arteries, and tendons of the superficial and deep flexors of the fingers and some of the muscles of the little finger and thumb. It rests on the palmar interossei and metacarpal bones near their carpal ends. **Position of the Arches.**—**The Superficial.**—Extend the thumb till it lies at right angles to the hand, and then draw a line across the palm on a level with its lower margin. The **deep arch** lies fully a finger's breadth nearer the carpus.

Branches.—(*a*) From the **superficial arch** are given off

(1) four digital arteries which supply the little finger, the ring finger, middle finger, and the ulnar side of the index finger. These vessels bifurcate half an inch above the clefts between the fingers; (2) the deep or communicating branch; (3) recurrent branches which pass upwards towards the annular ligament, (*b*) From the deep arch (1) Recurrent branches which ascend and anastomose with branches from the anterior carpal arch; (2) superior perforating, three in number, which pass backwards through the upper part of the last three interosseous spaces, to anastomose with the dorsal interosseous arteries; (3) the palmar interosseous arteries, three in number, which lie in front of the palmar interosseous muscles, and anastomose at the clefts of the fingers, with the digital branches from the superficial arch,

If both the radial and ulnar arteries are ligatured, the blood reaches the palm from the anterior and posterior interosseous arteries through the anterior and posterior carpal arches which communicate with the deep palmar arch. There is usually a small artery accompanying the median nerve into the palm ('*comes nervi mediani*'), but this branch is sometimes of large size, and joins the superficial palmar arch. It arises from the anterior interosseous, and it is well to bear in mind the possible existence of this branch. Hence it is not advisable to tie the radial and ulnar arteries for wounds of the palmar arches, as the blood will still reach the wound. It is better to apply a graduated compress or plug, together with acute flexion of the wrist and elbow joints, as we wish as far as possible to avoid an extensive wound of the palm, on account of the resulting cicatrix. Should this be insufficient to

control the hæmorrhage it is better at once to ligature the brachial, as it is more effectual and not more difficult than the double operation of tying the radial and ulnar arteries above the wrist. As, however, in many cases the artery is only *wounded*, it is evident that before resorting to severe measures, one should make certain that the vessel is completely cut across. This can easily be done through the original wound, and then very likely the artery will contract and retract sufficiently to allow the blood to clot and stop further hæmorrhage. The deep palmar arch, however, may be readily ligatured from the dorsum after excision of the upper end of the third metacarpal bone (Delorme).

In the palm, the digital arteries and nerves lie on the interosseous muscles *between* the metacarpal bones, and, therefore, incisions in this region should be made over these bones. The arteries are superficial to the nerves, and they bifurcate about half an inch from the clefts of the fingers (except the most internal branch), and run along their *sides*: hence incisions should not be made at the sides of the fingers. The relation between the nerves and the arteries differs in the palm and in the fingers; in the palm the arteries are superficial to the nerves, but in the fingers they are deeper than the nerves.

CHAPTER X.

ARTERIES OF THE ABDOMEN.

The Abdominal Aorta.—This vessel has been tied several times immediately above its point of bifurcation, or between that point and the origin of the inferior mesenteric artery, but without success; all the patients having died within periods varying from a few hours to ten days, the greater number having died within twenty-four hours. It is usually tied behind the peritoneum, although Sir ASTLEY COOPER, who was the first to tie the vessel, made his incision through the peritoneum. **Origin.**—It is the direct continuation of the descending thoracic aorta. **Extent.**—From the front of the body of the last dorsal vertebra to the left side of the body of the fourth lumbar vertebra, where it bifurcates into the common iliacs, a little to the left of the mesial line. Its point of bifurcation corresponds very nearly to the highest part of the crest of the ilium, or a little below and to the left of the umbilicus. **Course.**—From the middle line, at its origin, to a point a little to the left of the same line at its bifurcation; or, from the apex of the arch formed by the tenth rib on the left side to a point slightly internal to the anterior superior iliac spine. **Relations.**—In front—(1) Transverse part of the duodenum; (2) peritoneum; (3) aortic plexus of nerves; (4) lesser omentum and

stomach; (5) branches of cœlic axis and solar plexus; (6) splenic vein; (7) pancreas; (8) left renal vein; (9) mesentery and small intestines. On its left side—The left gangliated cord of sympathetic and left semi-lunar ganglion. On its right side—(1) The inferior vena cava; (2) vena azygos major; (3) receptaculum chyli. Behind it there is—(1) The left lumbar veins; (2) the vertebral column and thoracic duct; (4) right crus of diaphragm; (5) right semi-lunar ganglion.

Incisions.—First form, through the peritoneum. Make a straight incision four or five inches long in the middle line, curving round the umbilicus, which should correspond to the centre of the incision. Divide the skin, superficial fascia, linea alba, transversalis fascia, extra-peritoneal fat and peritoneum. Push the small intestines to the right side, and again divide the peritoneum as it covers the aorta; carefully separate the aortic plexus from the vessel, isolate it also from the inferior vena cava which lies to its right side, and pass the needle from the vein. Second form, without wounding the peritoneum. Make a semi-lunar incision six inches long on the left side of the abdomen, commencing a little below the anterior superior iliac spine, and fully an inch above Poupart's ligament, and carry it at first upwards and outwards, and then curving slightly forwards towards the umbilicus, end a little below the tenth rib. The structures divided and the method of operating, are similar to those described under ligature of the common iliac arteries *(quod vide)*.

Branches.—The most important branches, from a surgical point of view; are (1) the cœlic axis, the origin of which corresponds to a point four or five inches above the umbilicus; it is a short trunk and soon divides into

the gastric, hepatic, and splenic; (2) the superior mesenteric which arises about a quarter of an inch below the cœliac axis; (3) the renal arteries which correspond to a point three and a half inches above the umbilicus; and, (4) the inferior mesenteric about one inch above the umbilicus.

Collateral Circulation (Fig. 6).—(*a*) The deep epigastric branch (9) of the external iliac anastomosing with the terminal branches of the internal mammary branch (5) of the first part of the subclavian and the aortic intercostals (2); (*b*) The deep circumflex iliac branch (20) of the external iliac and ilio-lumbar (11) of the internal iliac anastomosing with the lower intercostals (2) and lumbar arteries (6) of the aorta; (*c*) The superior hæmorrhoidal termination of the inferior mesenteric anastomosing with the lateral sacral (14) and middle hæmorrhoidal branches of the internal iliac and middle sacral (10) of the aorta; (*d*) The extra-peritoneal plexus of Turner, which is described by that distinguished anatomist as 'a wide-meshed plexus of small arteries' lying in the fat outside the peritoneum. Above, it communicates with the perforating branches of the renal arteries, small twigs of the capsular, spermatic, colic, and pancreatic arteries, and below with the lower lumbar arteries, and with the ilio-lumbar, circumflex iliac, and epigastric branches of the iliac arteries. (*e*) Spermatic artery from the aorta anastomosing with the branches of the internal iliac to the ureter and vas deferens; (*f*) in the female, the ovarian anastomosing with the uterine.

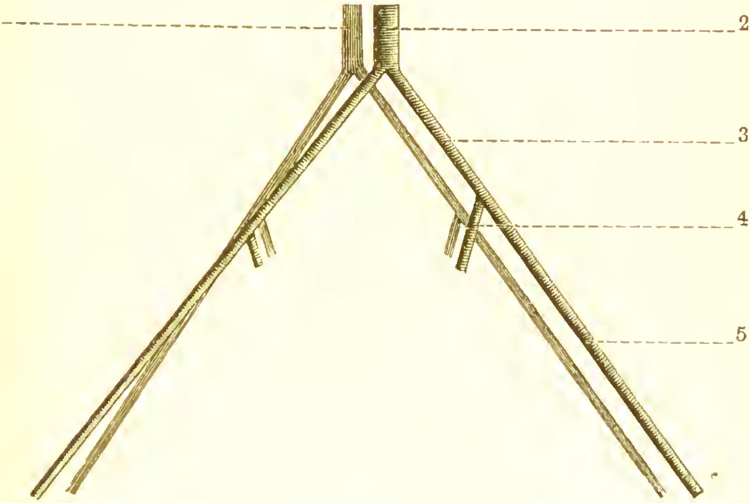
COMMON ILIACS.

Origin.—From the bifurcation of the abdominal aorta at the left side of the body of the fourth lumbar vertebra. **Extent.**—From its point of origin to the lumbo-sacral articulation, where it divides into internal and external iliac arteries. Each common iliac is from two to two and a-half inches in length; the *right* is necessarily a little longer than the left, because the point of division of the abdominal aorta is slightly to the left of the median line. The right is also somewhat larger than the left. **Course.**—Its course corresponds to the upper third of a line drawn from a point three-fourths of an inch below and a little to the left of the umbilicus, to a point midway between the symphysis pubis and the anterior superior iliac spine.

Relations.—The relations differ somewhat on the two sides. **Right Common Iliac.**—This vessel rests on its own vein at the lower part, and at the upper part crosses the vein of the opposite side. In front there are—(1) The small intestines (end of the ileum, and cæcum); (2) peritoneum; (3) sympathetic nerves; (4) crossed by the ureter near its termination. On its outer side are—(1) The right common iliac vein; (2) the commencement of the vena cava inferior. Its internal relations are unimportant. **Left Common Iliac.**—The left common iliac rests on the psoas magnus. In front are—(1) The rectum and sigmoid flexure; (2) peritoneum; (3) sympathetic nerves; (4) crossed by the ureter near it termination, and the inferior mesenteric vessels. On its outer side is the psoas magnus. On its inner side, the left common iliac vein. The relation of the common iliac veins to their corresponding arteries should be noted (Fig. 5). The

inferior vena cava is formed by the union of the two common iliac veins on the *right* side of the vertebral column, and both the veins lie on the *right* side of, and on a plane posterior to, their corresponding arteries. On the *right* side the vein is at first beneath and then to the outer side of the artery. The *left* vein lies entirely to the inner side of the left artery, and then passes beneath

Fig. 5.



ILIAC ARTERIES AND VEINS.

1. Inferior vena cava. 2. Abdominal aorta. 3. Common iliac artery. 4. Internal iliac artery. 5. External iliac artery.

the right common iliac vein to unite with that vein in the formation of the inferior vena cava at the right side of the fifth lumbar vertebra. The relation of the veins is a great trouble, and complicates the operation very much, more especially on the right side.

Position of Patient.—On his back with his shoulders

raised, his thighs somewhat flexed, and a small pillow under the loin of the side to be operated upon. The **operator**, of course, stands on the side to be operated upon. An **assistant** at first simply keeps the abdominal muscles moderately tense, but during the later stages of the operation when the peritoneum is stripped from the iliac fossa, he must be prepared to turn the patient round a little more on the sound side, and then with two broad copper spatulæ to hold the abdominal muscles, the peritoneum and intestines out of the way of the operator, for the wound is deep and the intestines are apt to roll back into it, and embarrass the operator.

Incision.—Make a semi-lunar incision about five inches in length, beginning about an inch below and an inch and a half external to the anterior superior iliac spine, at first passing upwards and outwards for two and a half inches, and then upwards and slightly inwards as far as may be deemed necessary. **Parts cut through.**—(1) Skin; (2) superficial fascia; (3) the aponeurosis of the external oblique muscle; (4) internal oblique; (5) transversalis muscle; (6) then the dull white transversalis fascia—in dividing this fascia, raise a small part at the lower end of the wound with the forceps, and make a small incision with the edge of the knife held horizontally, just as in opening the sheath of an artery, and afterwards enlarge this opening with a probe-pointed bistoury, a finger being introduced and the peritoneum detached, or, perhaps better, open it on Spence's hernia director. The special advantages of this director for the operation under consideration are, that it is broad and flat with the edges well rounded, and has a very blunt point, so that it is not likely to injure the peritoneum or intestines

during its introduction; and, further, the groove does not go quite up to the end, so that even should the peritoneum fold over its end it is not likely to be injured. This care is necessary in opening the transversalis fascia lest the peritoneum be wounded. The peritoneum is then separated carefully from the iliac fossa until the brim of the true pelvis is reached and the external iliac found, which will guide to the parent trunk, or the sacro-iliac synchondrosis may be taken as the guide if the artery is approached from above. The position of the spermatic vessels and the genito-crural nerve as they cross the external iliac, must be kept in mind, and also the ureter which crosses the end of the common or the beginning of the external iliac; but the ureter and spermatic vessels are usually more or less adherent to and follow the peritoneum as it is stripped up and pressed forwards. The needle should be passed *from* the vein—that is, in ligature of both vessels, from right to left. The clearing of the vessel is a difficult proceeding, but it must be done as carefully and well as possible by the finger nail or director. Some use an ordinary needle, while others prefer a rectangular one. The incision must not be carried too low down, or too far forwards, lest the deep circumflex iliac or the deep epigastric arteries be wounded, or even the structures passing through the internal abdominal ring. A branch of the deep circumflex iliac (or the artery itself) will be found between the transversalis and the internal oblique muscle, and must be secured at once.

Ligature of the common iliac may be rendered necessary on account of—(1) Aneurism of the external or internal iliacs; (2) hæmorrhage from the same vessels, either as

the result of a wound (*e.g.*, a gun-shot wound or stab) or a surgical operation; (3) secondary hæmorrhage after amputation of the upper part of the thigh. The operation is in itself a serious one, and in addition to the dangers dependent on the magnitude of the operation and the vessel tied, there is a further risk of inducing fatal peritonitis. The form of the incision will vary according to the point at which we wish to apply the ligature, and also upon the size of the aneurism. In every case the centre of the incision should be opposite to the point at which we wish to secure the artery.

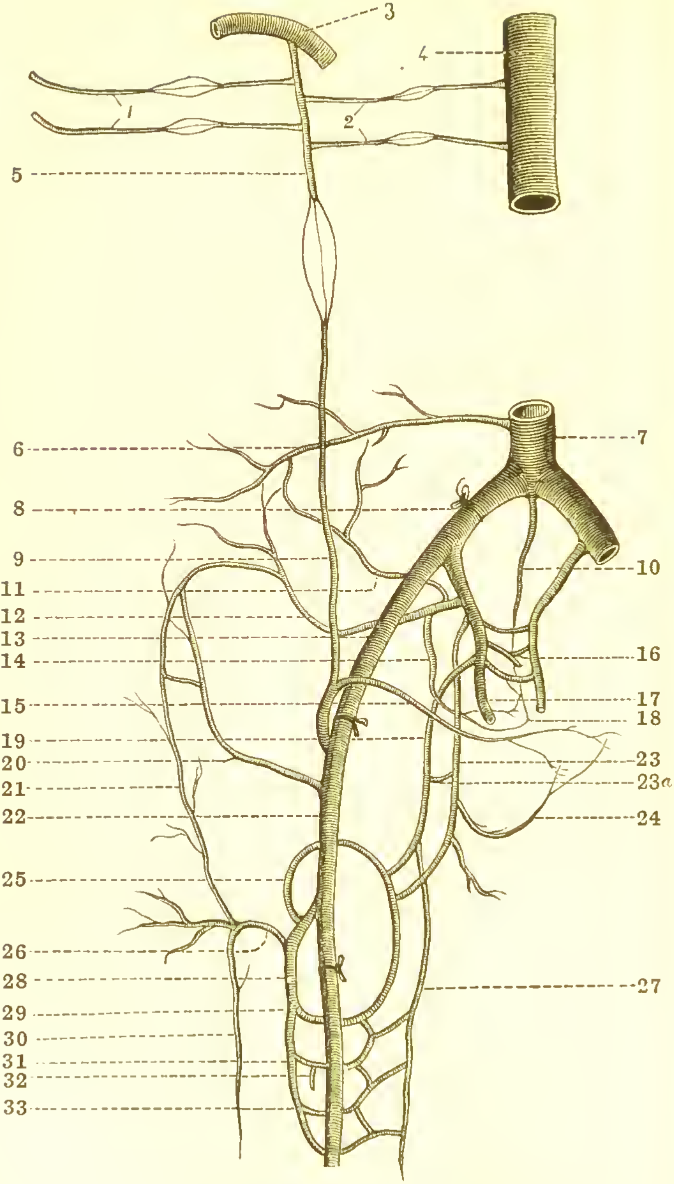
Collateral Circulation (Fig. 6).—(*a*) The deep epigastric branch (9) of the external iliac anastomosing with the internal mammary branch (5) of the subclavian and the aortic intercostals (2); (*b*) the deep circumflex iliac branch (20) of the external iliac and the ilio-lumbar (11) of the internal iliac anastomosing with the lower intercostals (2) and lumbar branches (6) of the aorta; (*c*) the lateral sacral (14) from the internal iliac anastomosing with the middle sacral (10) of aorta and the superior hæmorrhoidal of the inferior mesenteric; (*d*) the pubic branch of the deep epigastric (15) with the pubic branch of the obturator (24); (*e*) visceral branches of the internal iliac of the side tied anastomosing with the corresponding branches of the opposite side (16).

THE INTERNAL ILIAC.

Origin.—From the bifurcation of the common iliac at the lumbo-sacral articulation. **Extent and Course.**—From its point of origin it passes down almost immediately into the pelvis, and at the level of the great sacro-sciatic notch it divides into anterior and posterior

[To follow page 120.

Fig. 6.



Collateral Circulation of Abdomen
(After Smith and Walsham).

Explanation of Fig. 6.

1. Thoracic branches of the axillary. 2. Anastomoses between the internal mammary and the aortic intercostals. 3. Subclavian artery. 4. Aorta. 5. Internal mammary. 6. Last lumbar artery. 7. Aorta. 8. The common iliac. 9. The deep epigastric. 10. The middle sacral artery. 11. Ilio-lumbar artery. 12. Gluteal artery. 13. The external iliac. 14. The lateral sacral. 15. Pubic branch of deep epigastric. 16. Anastomoses between the visceral branches of the internal iliacs. 17. Pudic artery. 18. Anastomosis between the lateral and middle sacrals. 19. Sciatic artery. 20. Deep circumflex iliac. 21. Ascending branch of the external circumflex. 22. Femoral artery. 23. Obturator artery. 23*a*. Anastomosis between obturator and sciatic. 24. Pubic branch of obturator anastomosing with the pubic branch of the deep epigastric. 25. Internal circumflex. 26. External circumflex. 27. Comes nervi ischiadici. 28. Profunda artery. 29. First perforating. 30. Descending branch of the external circumflex. 31. Second perforating. 32. Nutrient artery of femur. 33. Third perforating.

trunks, which supply the pelvic walls and viscera. It is a short thick vessel, about an inch and a half in length (but may vary from half an inch to three inches), and is much smaller than the external iliac. In the the fœtus the internal iliac is called the hypogastric artery, and is twice as large as the external. It carries the blood from the fœtus to the placenta to be purified, and might therefore be looked upon in the same light as the pulmonary artery in the adult. Outside the belly of the child in utero, the two vessels twine round the umbilical vein, and are known as the umbilical arteries. After birth the greater part of the vessel is obliterated, and only remains as a fibrous cord; a small part of its root, however, remains pervious, and is known as the superior vesical artery. **Relations.**—In **front** are—(1) The peritoneum; (2) it is crossed by the ureter. **Behind** are (1) The internal iliac vein; (2) the lumbo-sacral cord; (3) part of the pyriformis. On the **outer** side it rests against the psoas magnus and external iliac vein. To its **inner** side, at the upper part, is the internal iliac vein (the internal iliac veins both lie internal to their corresponding arteries) (Fig. 5). The steps in the operation for the ligature of this vessel are precisely similar to those for the ligature of the common iliac *(quod vide)*, and the bifurcation of the common iliac being found, the internal iliac is traced from it down into the pelvis. Great care is necessary, when the artery is exposed, in passing the ligature, on account of the close relation of—(1) The ureter (which crosses it, but is usually turned aside with the peritoneum); (2) the external iliac vein, on its outer side; and (3) the internal iliac vein, on its inner side.

Branches.—*(A)* From the anterior division—(1) Vis-

ceral, to pelvic viscera—(*a*) Superior vesical, (*b*) inferior vesical, (*c*) middle hæmorrhoidal; and in the female there are two additional arteries—uterine and vaginal; (2) parietal, to walls of pelvis—(*a*) obturator, (*b*) pudic, (*c*) sciatic. (*B*) From **posterior** division they are all parietal—(*a*) gluteal, (*b*) Ilio-lumbar, (*c*) lateral sacral. The branches of the pudic are—(1) Inferior hæmorrhoidal; (2) superficial perinæal; (3) transverse perinæal; (4) artery to the bulb; (5) artery to the corpus cavernosum; (6) dorsal artery of the penis.

Collateral Circulation (Fig. 6).—(*a*) Middle sacral (10), from the aorta, anastomosing with the lateral sacral (14), from internal iliac. (*b*) Superior hæmorrhoidal, from the inferior mesenteric, anastomosing with the middle hæmorrhoidal, from the internal iliac, and inferior hæmorrhoidal from the pudic. (*c*) Sciatic (19), from the internal iliac, anastomosing with the internal circumflex branch of the profunda (25), from femoral; (*d*) the gluteal (12), from the internal iliac, anastomosing with the ascending branch of the external circumflex (21), from the profunda; (*e*) pubic branch of the deep epigastric (15), anastomosing with the pubic branch of the obturator (24); (*f*) ilio-lumbar (11), from the internal iliac, anastomosing with the lower lumbar arteries (6), and deep circumflex iliac (20); (*g*) the other visceral branches of the internal iliac, not included in the above list, with the corresponding branches from the other side (16).

The internal iliac has been tied for aneurism of its branches and for wounds. It was first tied by Stevens, of St Croix, for aneurism of the nates; the woman lived for three years after the operation. He made an incision five inches long external to, and parallel with,

the deep epigastric artery. Considering the serious nature of the operation, it has been wonderfully successful—probably on account of the free collateral circulation preventing any tendency to gangrene.

The Gluteal, Sciatic, and Pudic Arteries.—These three branches of the internal iliac artery are found in the gluteal region beneath the gluteus maximus muscle. They all emerge from the pelvis through the great sacro-sciatic foramen. The trunk of the **gluteal**, which is about the size of the ulnar artery, will be found between the pyriformis and the gluteus minimus muscles where it divides into a superficial and a deep division. The *superficial* part is distributed to the under surface of the gluteus maximus; the *deep* divides into superior and inferior branches—the *superior* runs along the middle curved line between the gluteus medius and minimus, and anastomoses with the ascending branch of the external circumflex artery; the *inferior* crosses the gluteus minimus to the great trochanter. The **Sciatic** artery appears below the pyriformis; it is about the same size as the lingual artery. It anastomoses with the external and the internal circumflex branches of the profunda femoris. Its branches are—(1) Muscular; (2) coccygeal; (3) comes nervi ischiadici; (4) anastomotic. The **Pudic** artery is seen close beside the sciatic. It winds out of the great sacro-sciatic foramen, crosses over the spine of the ischium, and re-enters the pelvis by the lesser sacro-sciatic foramen above the tendon of the obturator internus. As it lies on the spine of the ischium it has a vein on each side, the nerve to the obturator internus on its outer side, and the pudic nerve internal to it. The position of these three vessels may be indicated on the surface

thus: 'If a line is drawn from the posterior superior spinous process of the ilium to the tuberosity of the ischium the gluteal artery issues from the pelvis at a point about an inch external to the junction of the upper and middle thirds of this line; the ischiatic and pudic arteries a couple of inches lower down.'—(CHIENE).

The three vessels are simply covered by the integumentary structures and the gluteus maximus, and may be reached for the purpose of ligature by **incisions** three or four inches long in the direction of the fibres of the gluteus maximus over the points indicating their respective positions; but in by far the greater number of cases the guide to the artery affected will be the pulsating aneurismal tumour. Of the three, the gluteal is the one most frequently affected. It is the vessel most frequently wounded in this region from sitting down on something sharp, or, for example, from the accidental collapse of the chamber utensil. Any of the three may be wounded by a punctured wound in this region. In cases of traumatic aneurism the best treatment to adopt is to perform the 'old operation;' failing this, the internal or even the common iliac may be ligatured.

The **Collateral Circulation** (Fig. 6) is carried on by anastomoses between the gluteal (12) and sciatic (19) arteries with the ascending branch of the external (21) and internal circumflex (25) branches of the profunda femoris; and in the case of the pudic by the anastomoses of its branches with the corresponding branches from the other side.

THE EXTERNAL ILIAC.

Origin.—From the bifurcation of the common iliac at the lumbo-sacral articulation. **Extent.**—From its

point of origin to Poupart's ligament. **Course.**—It runs along the brim of the true pelvis, and its course is indicated by the lower two-thirds of a line drawn from a point three-fourths of an inch below, and a little to the left of the umbilicus, to a point midway between the anterior superior iliac spine and the symphysis pubis. The artery, with its accompanying vein, are bound down to the psoas muscle in a common sheath of fascia. **Relations.**—In **front**—(1) The intestines; (2) peritoneum; (3) a process of iliac fascia; (4) spermatic vessels; (5) vas deferens (4 and 5 are more especially at its lower part); (6) genital branch of the genito-crural nerve; (7) circumflex iliac vein. To its **inner side**—(1) The external iliac vein; (2) the vas deferens. To its **outer side**, the psoas magnus. **Behind** it—(1) The external iliac vein (on the right side); (2) the psoas magnus. On the *left* side the vein is to the inner side of the artery in the whole of its course, but is beneath its upper part on the right side (Fig. 5).

The **patient** is to be placed in the recumbent position with his shoulders raised by pillows, and his knees semiflexed, to relax the abdominal muscles. The colon must be well emptied by an enema, the pubes shaved and the bladder emptied before beginning the operation. The **Surgeon** stands on the same side as the vessel about to be tied.

Incisions.—(1) Make a curved incision four or five inches long, with the convexity downwards and outwards, commencing about an inch external to the middle of Poupart's ligament and an equal distance above it, and carry it upwards and outwards parallel with the ligament, ending a little in front of and above the anterior superior iliac spine. This form of incision more easily

reaches the artery at its upper part away from the seat of the disease—supposing it to be tied for femoral aneurism. It is not, strictly speaking, ABERNETHY's incision; he made his incision in the course of the vessel. The above incision is said to leave a great tendency to hernia, due to the injury to, and the consequent weakening of, the muscular planes. Its chief advantage is that one may ligature the vessel at any part of its course, or even, if necessary, tie the common iliac, and it is therefore to be preferred when operating in cases of spontaneous aneurism. The structures divided and the steps of the operation are the same as in ligature of the common iliac (*quod vide*). After the peritoneum is stripped up, the loose cellular tissue sheath surrounding the vessel must be carefully scratched through with the finger nail aided by a director or the point of the aneurism needle; when sufficiently cleared pass the needle from within outwards to avoid injury to the vein. The incision must not be carried too far downwards lest the deep epigastric vessels, or the internal abdominal ring, and the structures passing through it, be implicated; further it should not be too near Poupart's ligament, lest the deep circumflex iliac artery be cut. Special care must be taken not to include the genital branch of the genito-crural nerve in the ligature, or wound the peritoneum. In four cases of ligature of this artery, the patients died from *tetanus*, probably from implication of the nerve in question. The chief causes of death after this operation are—(1) Gangrene, especially likely to occur when the deep epigastric is injured; (2) secondary hæmorrhage, especially when the vessel is diseased or when it is tied too near its origin, or

again when tied too near Poupart's ligament; (3) peritonitis.

(2) **Sir A. Cooper's Incision.**—Make a semi-lunar incision from near the anterior superior iliac spine to a little above the inner margin of the external abdominal ring. This incision chiefly exposes the artery at the lower part. The artery is more easily reached by this incision, but one is more apt to wound the deep epigastric, and certain to cut the peritoneum. Further the vessel is exposed too near the seat of the disease, the deep circumflex iliac artery and vein are in great danger, as well as the vas deferens and spermatic vessels: and should the vessel, when exposed, be found diseased it is impossible to prolong the incision upwards so as to tie the vessel at a higher point. The chief advantages, when compared with the previous operation, are—(1) That the peritoneum is less disturbed, and (2) there is less tendency to hernia afterwards. Cooper's operation is usually selected when it is found necessary to ligature the external iliac for secondary hæmorrhage after a wound or amputation, and where therefore the coats of the vessel are healthy, and more especially if the abdomen is thin and flat.

PECULIARITIES.—The deep epigastric may arise from any part of the external iliac between Poupart's ligament and two and a half inches above it. Not infrequently the obturator arises by a common trunk with the deep epigastric.

Branches.—Two branches are given off from this artery just above Poupart's ligament—(1) The deep epigastric; (2) the deep circumflex iliac.

Collateral Circulation (Fig. 6).—(*a*) The deep epigastric branch (9) anastomosing with the terminal

branches of the internal mammary (5) and aortic intercostals (2); (*b*) the deep circumflex iliac branch (20), and the ilio-lumbar branch (11) from the internal iliac, anastomosing with the lower intercostals (2), and lumbar branches of the aorta (6); (*c*) the gluteal artery (12) from internal iliac anastomosing with the external circumflex branch (26) of the profunda femoris; (*d*) the sciatic artery (19) from the internal iliac anastomosing with the internal circumflex branch of the profunda (25); (*e*) the obturator artery (23) from the internal iliac anastomosing with the internal circumflex branch of the profunda (23*a*).

CHAPTER XI.

ARTERIES OF THE LOWER EXTREMITY.

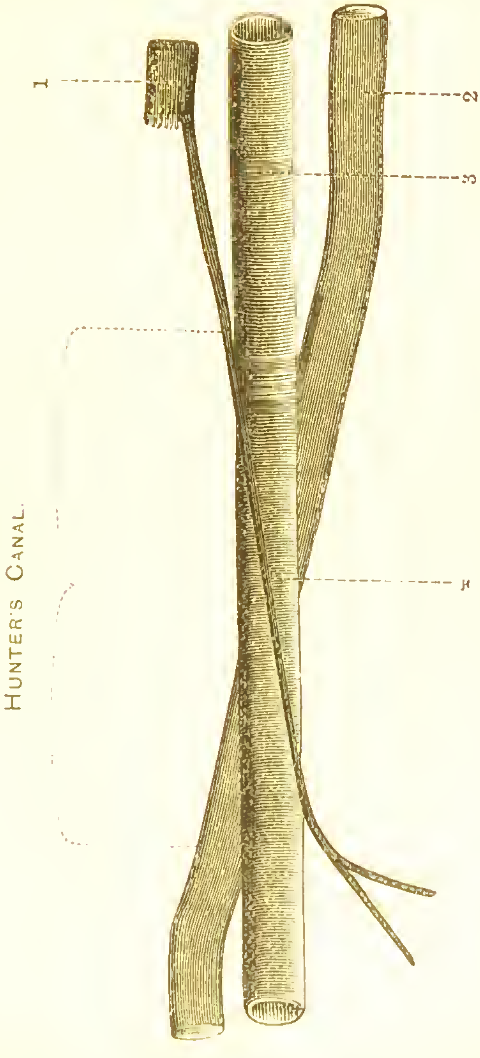
The Femoral Artery.—Origin.—It is the direct continuation of the external iliac artery. **Extent.**—It extends from Poupart's ligament to the opening in the adductor magnus; this corresponds to the upper two-thirds of the thigh. **Course.**—Flex the thigh upon the abdomen, and rotate it a little outwards, and the course is then indicated by a line drawn from a point midway between the anterior superior iliac spine and the symphysis pubis, to the inner side of the internal condyle of the femur. The artery at first lies immediately over the hip joint, but as it passes downwards it takes an oblique course along the inner side of the femur, and finally passes behind it as it enters the popliteal space through the opening in the adductor magnus. In applying pressure, therefore, to the femoral artery in the upper part of its course we ought to press directly backwards against the body of the pubes, or the ilio-pectineal eminence, but, if applied to the middle third of the thigh, as the artery lies in Hunter's canal, the pressure must be directed outwards towards the femur. It is well to know that the names applied by Surgeons to different parts of this artery, and the names applied by anatomists are not quite the same. The '*common femoral*' of Surgeons is the femoral artery

before it has given off its profunda branch, and is usually about one inch and a-half in length; below this point it is known as the '*superficial femoral.*' But the *common femoral* and the *superficial femoral* of Surgeons form simply the femoral of Anatomists; while the '*deep femoral*' of Surgeons, is the *profunda* branch of Anatomists.

Relations.—The artery is divided into a superficial and a deep part. The *superficial* part is contained in Scarpa's triangle, and corresponds to about the upper third of the thigh; the *deep* part is contained in Hunter's canal, and corresponds to the middle third of the thigh. In front of the artery, as it lies in Scarpa's triangle, we have—(1) Skin; (2) superficial fascia; (3) deep fascia; (4) cribriform fascia; (5) some large tributaries of the long saphenous vein; (6) anterior part of femoral sheath; (7) the internal cutaneous nerve just at the apex of the space. The crural branch of the genito-crural is found in the sheath, lying in front of the femoral artery; it leaves the sheath by piercing its outer border. As it lies in Hunter's canal, in addition to the superficial structures, we find covering it (8) the sartorius muscle; (9) roof of Hunter's canal; (10) the long saphenous nerve. Behind it there is—(1) The psoas muscle which separates it from the margin of the pelvis and the capsule of the hip joint; (2) the nerve to the pectineus; (3) the femoral vein; (4) the pectineus; (5) the adductor longus; and (6) part of the adductor magnus. On the inner side—(1) The femoral vein (at the upper part); (2) the adductor longus; (3) the sartorius. On the outer side—(1) The anterior crural nerve, which lies about a quarter of an inch from the vessel, a few fibres of the

psoas muscle intervening; (2) the vastus internus; (3) the femoral vein (at the lower part); (4) the internal

Fig. 7.



1. Anterior crural nerve. 2. Femoral vein. 3. Femoral artery. 4. Long saphenous nerve, which leaves the canal just above its termination.

cutaneous nerve; (5) the long saphenous nerve; (6) the nerve to the vastus internus. The femoral vein (Fig. 7)

is at first on the same plane, and on the inner side of, and close to the artery; but in its course downwards it gradually passes behind the artery, until, when it reaches the apex of Scarpa's triangle, it lies directly behind the artery; it then gradually passes to its outer side. The following is the arrangement of vessels at the apex of Scarpa's triangle—(1) Femoral artery; (2) femoral vein; (3) profunda vein; (4) profunda artery; hence, if a person receives a stab or bullet wound at this point, these vessels are liable to be injured. The adductor longus muscle separates the femoral vessels from the profunda vessels in this region. The femoral artery may be tied (1) above the origin of the profunda, *i.e.*, the common femoral; (2) the superficial femoral at the apex of Scarpa's triangle; and (3) the superficial femoral in Hunter's canal.

The Common Femoral.—This has been anything but a successful operation. There are various reasons for this—(1) It is a short trunk, the usual length being about an inch and a half, and it may be much shorter. (2) The large number of branches given off in the neighbourhood, so that it is next to impossible for a satisfactory clot to form. These branches are—(*a*) The deep epigastric and deep circumflex iliac, just above its origin; (*b*) the profunda one to two inches below; (*c*) occasionally also one of the circumflex arteries, usually the internal; (*d*) three or four small branches—superficial epigastric, superficial circumflex iliac, superficial external pudic, and deep external pudic. It may be said that these are so small that they are not worth taking into account, but this is by no means the case; they bleed very freely and more especially if they are cut near their origin, for then

the cut end retracts so much that the wound becomes, for all practical purposes, equivalent to a wound of the common femoral itself. (3) Another possible objection to this operation is that the cicatrix, by its contraction, may interfere with the integrity of the femoral ring.

The vessel may be reached either by (1) **A vertical incision**, two inches long, right over the artery, beginning at Poupart's ligament, or by (2) a **transverse incision**, two and a half inches long, across the course of the vessel, about an inch below Poupart's ligament. In either case the structures cut through are (1) Skin; (2) superficial fascia with the superficial vessels, nerves, and lymphatics in this region; (3) iliac part of the deep fascia and branches of the genito-crural, and anterior crural nerves; (4) the femoral sheath, which must be opened over the vessel. Carefully isolate the artery from the surrounding structures and pass the needle from the inner side, *i.e. from* the vein. As already mentioned, the results of this operation are by no means satisfactory. (1) Gangrene has followed in several cases; but the great cause of death is (2) secondary haemorrhage. Hence in cases where it might be deemed expedient to tie the vessel at this point, it is better not to do so, but rather to ligature the external iliac at once.

Collateral Circulation (*Fig. 8*).—(*a*) Sciatic (3), from the internal iliac, anastomosing with the internal circumflex (11), external circumflex (31), and perforating arteries (15, 18, 19); (*b*) the obturator (4) from the internal iliac with the internal circumflex of the profunda (11); (*c*) gluteal (1) from the internal iliac, with the ascending branch of the external circumflex of

the profunda (7); (*d*) deep external pudic with the superficial perineal artery.

(2) **Ligature at the Apex of Scarpa's Triangle.**—The safest place at which to apply a ligature is about five inches from Poupart's ligament. This is usually well out of the way of the profunda, as this vessel has not been known to take origin lower down than four inches from the origin of the femoral.

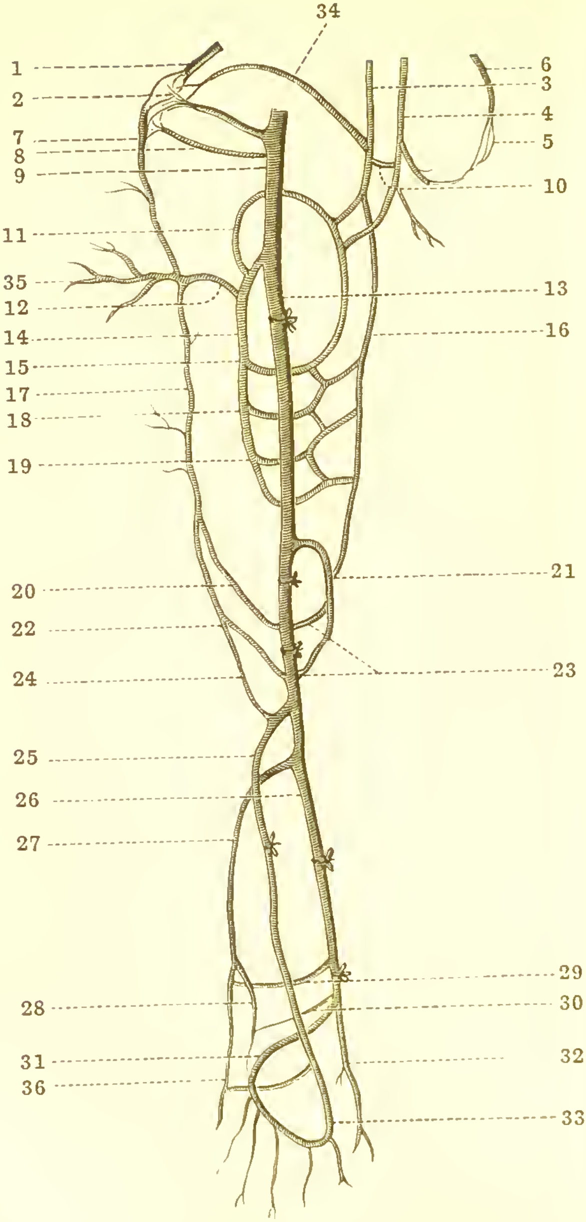
THE OPERATION.

Position of the Patient.—He should be recumbent, his thigh flexed and rotated outwards, with the knee bent and resting against a pillow. The **Surgeon** stands on the outer side of the limb.

Incision.—Ascertain the position of any large superficial vein, stretch but do not displace the skin with the left hand, and then make an incision four or five inches long in the course of the vessel, its centre corresponding to the point at which the artery is to be tied. This incision is not parallel with the inner edge of the sartorius, but will cross that muscle obliquely, and it must not be made too far inwards lest the long saphenous vein be wounded. We **cut through**—(1) The skin; (2) superficial fascia and fatty tissue; (3) the deep fascia forming the sheath of the sartorius, which at this point crosses the artery obliquely. An **assistant** with blunt hooks now keeps the edges of the wound in the fascia apart, and the Surgeon with scalpel and forceps proceeds to define the inner edge of the sartorius, which is then to be gently drawn towards the outer side and held there by a broad copper spatula. (4) A small opening is next to be made in the femoral sheath, and the side of the opening furthest from the operator

[*To follow page 134.*

Fig. 8.



Collateral Circulation of the Lower Extremity
(After Smith and Walsham)

Explanation of Fig. 8.

1. Gluteal artery. 2. Anastomoses between the gluteal, sciatic, external circumflex, deep circumflex iliac, and superficial circumflex iliac arteries. 3. Sciatic artery. 4. Obturator artery. 5. Anastomosis between the pubic branches of deep epigastric and obturator arteries. 6. Pubic branch of deep epigastric. 7. Ascending branch of external circumflex. 8. Superficial circumflex iliac. 9. Common femoral. 10. Anastomosis between obturator and sciatic arteries. 11. Internal circumflex artery. 12. External circumflex artery. 13. Superficial femoral. 14. Deep femoral *(profunda)*. 15. First perforating. 16. Comes nervi ischiadici. 17. Descending branch of external circumflex. 18. Second perforating. 19. Third perforating. 20. Superior external articular. 21. Anastomotica magna. 22. Inferior external articular. 23. Superior and inferior internal articular arteries. 24. Anterior tibial recurrent. 25. Anterior tibial. 26. Posterior tibial. 27. Peroneal. 28. Anterior peroneal. 29. Communicating branch between the peroneal and posterior tibial. 30. Malleolar branches. 31. External plantar artery. 32. Internal plantar artery. 33. Dorsalis pedis. 34. Branch of sciatic artery. 35. Transverse branch of the external circumflex (near the bottom of p. 133, fifth line from bottom, *for* 34, *read* 35). 36. Anastomosis behind external malleolus.

is then to be secured by a pair of Wells's forceps and given to an assistant; this prevents the possibility of losing the opening. After this (5) the proper sheath of the vessel, which is then cleared and ligatured in the usual way. At the point where the artery is ligatured the vein lies behind it, so that it matters little from which side the needle is passed; but on account of this relation, great care is necessary in clearing the artery and passing the needle; and not only does the vein lie immediately behind the artery, but it is very firmly connected to it, so that the artery must be completely cleared before we attempt to pass the ligature, which must then be passed without using force. The vein is often rather to the inner side at this point, so that on the whole it might be as well to pass the needle from the inner side. Some Surgeons advise that it should be passed unarmed and then threaded and withdrawn, as, they say, there is less risk of wounding the femoral vein by so doing. But, while the artery should be cleared completely, due care must be taken at the same time to avoid undue disturbance of the parts, lest the '*vasa vasorum*' supplying the coats of the vessel be unnecessarily injured, and lead to death of that part of the vessel.

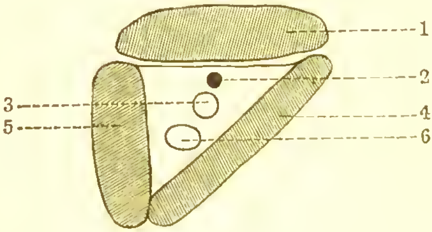
This is a very successful operation. The more important untoward accidents are—(1) Gangrene; (2) wound of the vein; and (3) secondary hæmorrhage. (For the preventive treatment of gangrene see p. 29). 1. **Gangrene** is especially apt to follow if the vein is injured. The best way to avoid this is to clean a *small* part of the vessel thoroughly *with scalpel and dissecting forceps* (BELL). No blunt instruments, such as directors, &c. are admissible. 2. **Wound of the vein**

is very frequently fatal from septic phlebitis or gangrene. Should this untoward accident occur, the ligature should be withdrawn, and a new opening made in the sheath half an inch higher up and the ligature reapplied there. 3. In **secondary hæmorrhage** there are various courses open—(*a*) The graduated compress: (*b*) ligature of the external iliac or superficial femoral; this is usually followed by gangrene; (*c*) tie the bleeding point—usually the distal side; (*d*) if everything else fail, amputate.

LIGATURE IN HUNTER'S CANAL.

This operation is rarely performed now-a-days, as the vessel is too deeply placed, and besides, ligature at the apex of Scarpa's triangle gives better results. 'Hunter's canal' is formed by an aponeurotic expansion thrown across from the adductors longus and magnus on the

Fig. 9.



SECTION THROUGH HUNTER'S CANAL, RIGHT SIDE.

1. Sartorius, lying on the roof of the canal. 2. Long saphenous nerve. 3. Femoral artery. 4. Adductor magnus, forming the inner boundary of the canal. 5. Vastus internus forming its outer boundary. 6. Femoral vein.

inner side to the vastus internus on the outer side. It is triangular in shape, the base being formed by the expansion already alluded to, and extends from the

apex of Scarpa's triangle to the opening in the adductor magnus, and corresponds, therefore, to the middle third of the thigh. It encloses the femoral artery and vein, and the long saphenous nerve—the vein being at first behind, and then to the outer side of the artery, while the nerve is above it, and crosses from its outer to its inner side (Fig. 7).

Incision.—An incision, three or four inches long, should be made a finger's-breadth internal to, and parallel with, the line that indicates the course of the artery, so as to cut down on the outer border of the sartorius, and at the same time avoiding the internal saphenous vein (BECK). **Structures cut through**.—(1) Skin: (2) superficial fascia and fatty tissue; (3) through the fascia forming the sheath of the sartorius, and expose the edge of that muscle, and draw it well to the inner side. Next divide (4) the roof of Hunter's canal with the point of the knife and then enlarge the opening with a probe-pointed bistoury; the saphenous nerve is then to be drawn aside, and the proper sheath of the vessel opened, and the artery cleared to the requisite extent, and the ligature passed from the outer to the inner side, and, if possible, about an inch above the origin of the anastomotica magna.

PECULIARITIES.—(1) In four cases a double superficial femoral was found, the two divisions reuniting again near the opening in the adductor magnus to form a single popliteal. (2) The femoral has been found situated at the back of the thigh, passing through the great sacro-sciatic foramen. (3) Sometimes the common femoral is very short or altogether absent.

Branches of the Femoral.—(1) The superficial epigastric; (2) the superficial circumflex iliac; (3) the

superior external pudic; (4) the inferior external pudic; (5) the profunda branch; (6) the anastomotica magna, which is given off in the lower part of Hunter's canal. The only branch which requires special notice is the profunda branch.

The Profunda Artery.—(Deep femoral).—This branch arises from the outer and posterior part of the femoral artery about an inch and a half from its commencement. At first it passes downwards and outwards, then curves inwards behind the femoral artery and the adductor longus muscle (this muscle separating the two vessels), and then passes downwards, at first lying between the adductors longus and brevis, and afterwards between the adductors longus and magnus, and terminates by piercing this latter muscle. **Relations.**—It **lies on**—(1) The iliacus, (2) the pectineus, (3) the adductor brevis, (4) the adductor magnus. In **front** of it (besides the structures covering the femoral artery) we have—(1) The femoral and profunda veins, (2) the adductor longus. To its **outer** side is the vastus internus. It may be ligatured near its origin by the same incision as that used for ligature of the femoral in the lower part of Scarpa's triangle; or, lower down by following it inwards behind the adductor longus muscle, but great care would be necessary on account of its relations to its own vein, and also to the femoral vessels.

Branches of the Profunda.—(1) The external circumflex—this branch passes outwards beneath the sartorius and rectus, and divides into—(*a*) Ascending branches which pass upwards and anastomose with the gluteal and the circumflex iliac arteries; (*b*) transverse branches which pass outwards over the crureus, and anastomose on the back of the thigh with the internal circumflex.

gluteal, sciatic, and superior perforating arteries; (*c*) descending branches which pass downwards towards the knee, and anastomose with the superior articular branches of the popliteal artery. (2) The internal circumflex — this vessel passes directly backwards towards the gluteal region, and there anastomoses with the gluteal, sciatic, and superior perforating arteries. It gives a small branch to the hip joint. It arises from the posterior surface of the profunda, and disappears by passing between the pectineus and psoas muscles, and continuing its course backwards between the obturator externus, and the adductor brevis, and finally appearing behind, between the adductor magnus and the quadratus femoris muscles. (3) The three perforating arteries which pass backwards *close* to the femur, and appear on the posterior surface of the adductor magnus. These arteries form a regular chain of anastomoses in the back of the thigh, connected above with the gluteal and sciatic arteries, and below with the anastomotica magna and the superior articular branches of the popliteal.

PECULIARITIES.—It arises sometimes from the inner side of the femoral. It usually arises from one to two inches from the beginning of the femoral. In a few cases it was less than an inch; more rarely it may arise just under Poupart's ligament, and in one case it came from the external iliac. It has been known to arise four inches below the origin of the common femoral.

Collateral Circulation (fig. 8).—(1) In ligature of the superficial femoral—(*a*) The descending branches of the external circumflex above (17), anastomosing with the superior articular branches of the popliteal (20), and anastomotica magna below (21); (*b*) the obturator artery above (4), anastomosing with the internal circum-

flex artery (11), muscular branches, and anastomotica magna below (21); (*c*) the chain of anastomoses already mentioned, formed by the perforating arteries, inosculating above with the gluteal (1), sciatic (34), and ascending (7) and transverse branches of the external circumflex (35), and below with the anastomotica magna (21) and articular arteries (23, 20, 22): (*d*) terminal branches of the profunda and sciatic arteries (21) above, anastomosing with the anastomotica magna below. (2) **In ligature of the deep femoral**—(*a*) The descending branches of the external circumflex above (17), anastomosing with the anastomotica magna (21) and superior articular arteries below (20, 23); (*b*) branches of the internal circumflex above (11), anastomosing with the perforating arteries below (15, 18, 19).

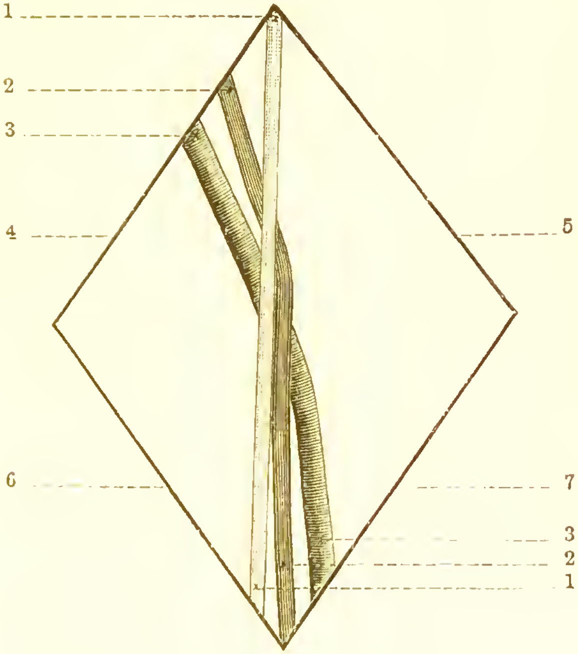
POPLITEAL ARTERY.

Origin.—It is the direct continuation of the femoral. **Extent.**—It extends from the opening in the adductor magnus to the lower border of the popliteus muscle, where it divides into the anterior and posterior tibials. Its point of division corresponds to the lower part of the tubercle of the tibia in front. **Course.**—It passes from the inner side of the femur to the middle of the popliteal space, exactly behind the knee joint, and then passes straight downwards. The artery lies deeply in the space, and is covered and crossed by the internal popliteal nerve and the popliteal vein; both vein and nerve crossing the artery from without inwards. Behind the knee joint, the artery lies in the middle of the space, and is covered (as looked at from behind) by the nerve and vein, so that if a person receive a stab in

this region all the three structures may be injured, or perhaps divided, in the order of nerve, vein, artery.

Ligature of this artery is seldom performed, but it may be rendered necessary for wound, for ruptured

Fig. 10.



RIGHT POPLITEAL SPACE, FROM BEHIND.

1. 1. Internal popliteal nerve. 2. 2. Popliteal vein. 3. 3. Popliteal artery. 4. Internal superior boundary—semitendinosus and semimembranosus. 5. External superior boundary—biceps femoris. 6 Internal inferior boundary—inner head of gastrocnemius. 7. External inferior boundary—outer head of gastrocnemius and plantaris.

artery or for suppuration of an aneurismal sac in this position. It may be exposed by—(1) a median incision either over the centre of the space or over its lower angle where it lies between the two heads of the gastrocnemius; (2) by an incision on the inner side

above (JOBERT); (3) by an incision on the inner side below (MARSHALL). All the incisions should be about four inches long.

(1) Median Incision.—The patient should be laid on his face, and the Surgeon stands on the outer side and makes an incision in the middle line four inches long, carefully avoiding the external saphenous vein, which empties itself into the popliteal vein at the lower angle of the space. We cut through the skin, superficial fascia, cutaneous vessels and nerves, and deep, or popliteal, fascia; at this stage the limb must be flexed and the tendons, with the internal popliteal nerve carefully held aside with copper spatulæ. Then, by dissecting carefully down amongst the fatty tissue with the handle of the knife the operator next exposes the popliteal artery and vein, firmly bound together; the vessels must then be separated and the vein displaced to the side most convenient, and when the artery is cleared the needle must be passed from that side. The vein and the artery are very adherent, so that it is a very difficult proceeding to separate them and clear the artery for the ligature. The walls of the vein are said to be specially thick, resembling very closely, in fact, the coats of an artery. This may possibly account for the rarity with which this vein is ruptured. The circulation will be re-established by the superior articular anastomosing with the inferior articular, and other branches around the knee joint.

(2) To reach the vessel in its upper third by an incision from the inner side. The limb is to be placed in the same position as in ligature of the femoral. The guide is the posterior edge of the tendon of the adductor magnus, which is attached to the 'adductor tubercle.'

An incision three or four inches long is made parallel with this tendon, beginning at the junction of the middle with the posterior third of the thigh, avoiding, if possible, the long saphenous vein. After dividing the superficial structures and deep fascia, the tendons of the sartorius and internal hamstrings come into view, and must be displaced backwards by a copper spatula. Then with the finger feel for the tendon of the adductor magnus, and after this dissect carefully through the loose fatty tissue with the handle of the scalpel or a director till the artery is exposed. It is next to be cleared sufficiently, and the needle passed from the outer side to avoid the popliteal vein and the internal popliteal nerve which lie on that side of the artery in this position (Fig. 10).

(3) It may be ligatured in the **lower third** of its course, by MARSHALL'S plan, as it lies on the popliteus muscle, and covered by the gastrocnemius. An **incision** three or four inches long is made a little behind and parallel with the inner border of the tibia, avoiding the long saphenous vein. By cutting through the superficial structures and deep fascia and displacing the inner head of the gastrocnemius backwards the vessel may be reached and ligatured. The relation of the popliteal vein and internal popliteal nerve, both of which by this time lie rather on the inner side of the vessel (Fig. 10), will complicate the operation considerably. This, however, matters little, as the operation is of no practical utility.

POSTERIOR TIBIAL ARTERY.

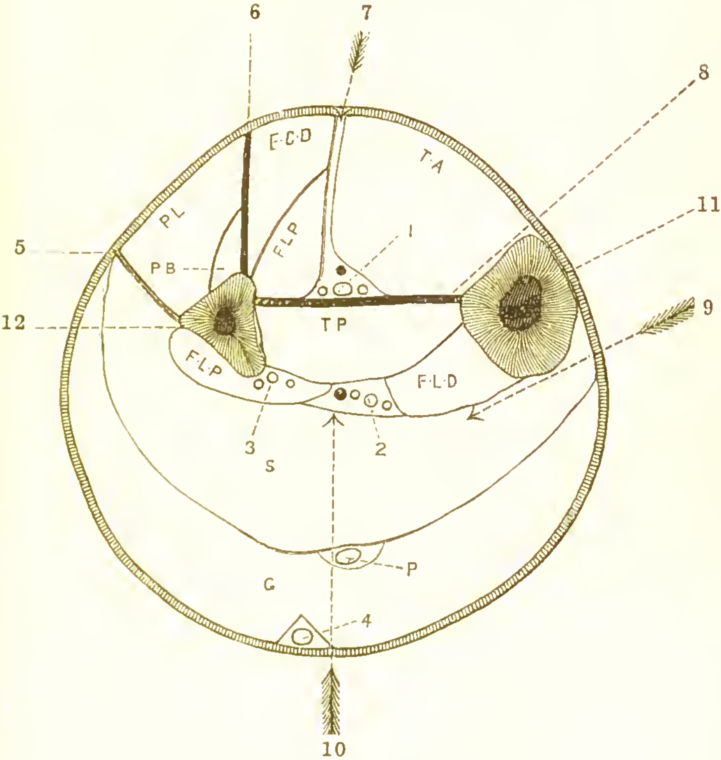
Origin.—From the bifurcation of the popliteal artery at the lower border of the popliteus muscle. **Extent.**

From its point of origin to the inner side of the os calcis, where it ends by dividing into the internal and the external plantar arteries beneath the internal annular ligament. It lies between the superficial and the deep layers of muscles on the back of the leg (Fig. 11). **Course.**—Its course is indicated by a line drawn from a point one inch below the middle of the popliteal space, and in the middle line of the limb, to a point a finger's breadth behind the internal malleolus. **Relations.**—It is **covered by**—(1) Skin and fascia; (2) gastrocnemius; (3) soleus; (4) plantaris; (5) a tendinous arch, covering it, which stretches between the flexor longus digitorum and the flexor longus hallucis; (6) posterior tibial nerve which crosses it at its upper part from within outwards. It **lies upon**—(1) The tibialis posticus; (2) the flexor longus digitorum; (3) the lower end of the tibia (this is of importance in compression). On its **inner** side—the posterior tibial nerve (in its upper third). On its **outer** side—the posterior tibial nerve (in its lower two-thirds). It may be ligatured—(1) In the middle third of the leg, or (2) behind the internal malleolus.

1. In the Middle Third of the Leg.—The vessel may be reached by two incisions—(*a*) **The Lateral Incision** (Figs. 11, 9).—An incision about four inches long is made parallel with the inner border of the tibia and fully half an inch behind it, avoiding the internal saphenous vein. The **patient** is placed in the recumbent position, his knee is to be flexed, his foot fully extended, and the limb laid on its outer side, resting against a pillow; the **Surgeon** stands on the outer side of the limb. By this incision we first **divide** skin and superficial fascia and fatty tissue; the deep fascia is next opened, and the internal

edge of the inner head of the gastrocnemius exposed, which must be displaced backwards by a broad copper

Fig. 11.



SECTION THROUGH THE CALF.

1. Anterior tibial vessels and nerves. 2. Posterior tibial vessels and nerves 3. Peroneal vessels. 4. Short saphenous vein. 5. Septum between peronei and posterior muscles. 6. Strong septum between peronei and anterior group of muscles. 7. Weak septum in anterior group, through which the anterior tibial artery is reached. 8. Interosseous membrane. 9. To show position of lateral incision. 10. To show position of direct incision (GUTHRIE'S). 11. Tibia. 12. Fibula.

The names of the muscles are indicated by their initial letters.

spatula. The tibial origin of the soleus is now seen, and is to be divided along the whole length of the

external incision, about half an inch from its attachment to the tibia. In dividing it, the edge of the knife must be turned towards the tibia, and at first only cut through its muscular fibres, exposing its deep tendon: when this is thoroughly exposed, make an opening in it after the manner of opening the sheath of an artery and complete its division on a director. The divided soleus is next hooked aside, along with the gastrocnemius, and the space where the artery lies then comes into view; at this point it is accompanied by its venæ comites, and at the upper part of the incision the posterior tibial nerve lies internal to it, then over it, and lastly, at the lower part of the wound, to its outer side. These structures rest on the fascia, covering the deep muscles (tibialis posticus and flexor longus digitorum), and are covered by a thin layer of fascia. This fascia must be opened and the artery cleared and ligatured in the usual way, the needle being passed from the nerve.

It is important not to open the fascia covering the deep muscles, for then it is very easy to pass beneath the flexor longus digitorum and so miss the artery altogether. There is often a tendinous intersection in the soleus, which must not be mistaken for its deep tendon.

(2) The second form is that recommended by the late Mr GUTHRIE, and is known as the mesial or direct incision (Figs. 11, 10). The patient is placed in the same position as in ligature of the popliteal artery in the centre of the popliteal space, and the Surgeon stands as before. After the superficial structures are divided, the knee should be flexed and the foot extended in order to relax the muscles through which the operator has to

pass to reach the artery. An incision six or seven inches long is made in the mesial line of the leg, in the course of the vessel, beginning about two inches below the middle of the popliteal space, and dividing the skin and fascia. The external or short saphenous vein is then separated and held aside, and the *septum* between the two heads of the gastrocnemius is divided to the same extent as the superficial incision, and the two heads separated. The muscular fibres of the soleus are next cut through, and its deep tendon opened as in the last operation, and then the aponeurotic arch covering the vessels is divided, when the posterior tibial nerve will come into view, with the posterior tibial artery and its venæ comites, to its *inner* side. The artery is then cleared and the ligature passed *from* the nerve.

2. **Ligature of the Vessel at the Inner Ankle.**—Here the artery is quite superficial, and its pulsations may be detected during life. It lies between the tendons of the flexor longus digitorum and the flexor longus hallucis, with a vein on either side, and the posterior tibial nerve immediately behind it (that is, nearer the heel). The limb is to be placed in the same position as in ligature of the artery higher up by the lateral incision: only in the later stages of the operation the foot had better be flexed and everted. The Surgeon stands as in the previous operation. Make a semilunar incision two inches long, a finger's breadth behind the internal malleolus, towards which the concavity of the incision is to be directed; the incision must not be too near the tibia lest the sheath of the tendons be opened. Cut through the skin and superficial fascia, when the deep fascia, the internal annular ligament, covering the vessels is brought into view and divided.

and the posterior tibial nerve is then seen, and the artery will be found a little nearer the tibia; separate the artery from its venæ comites and ligature in the usual manner. The structures at the inner ankle all lie in an oblique plane, and unless the operator keep to the concave side of the incision he is very apt to miss the artery altogether. The artery may also be exposed in the lower third of the leg by a vertical incision midway between the internal malleolus and the tendo Achillis; in this situation it will be found lying on the flexor longus digitorum.

Branches.—(1) Nutrient to tibia; this is the largest nutrient branch in the body; (2) peroneal; (3) muscular; (4) communicating to peroneal; (5) calcanean; (6) the plantar arteries.

The Peroneal Branch requires special notice. It is often as large as, or even larger than, the posterior tibial artery, and arises from that vessel about an inch and a half from its origin. At first it passes obliquely outwards towards the fibula, and then passes downwards behind, and lying close to that bone until about two inches above the ankle, where it divides into its terminal branches. It first lies on the tibialis posticus, and then passes into the substance of the flexor longus hallucis, in which it lies for the rest of its extent. The artery may be ligatured by the same incision as that recommended by Guthrie for ligature of the posterior tibial artery. The posterior tibal nerve forms a safe guide to either of these vessels; it lies almost exactly between, and in close relation to them both—the posterior tibial artery lying immediately to its inner side, while the peroneal branch occupies the same position on its outer side. The structures divided,

therefore, are the same in both cases. It may also be reached in the middle of the leg by an incision three inches long, parallel with and a finger's breadth behind the outer border of the fibula. After the superficial structures are divided, cut through the fibular origin of the soleus, and then separate the flexor longus hallucis from its origin, and towards its inner edge the vessel will usually be found. For this operation the leg must be flexed and laid on its inner side and the Surgeon stands on the outer side.

Branches of the Peroneal Artery.—(1) Muscular; (2) nutrient to fibula; (3) communicating to posterior tibial; (4) anterior peroneal, which is given off about two inches above the ankle, pierces the interosseous membrane, and passes down in front of the fibula to the outer ankle, and there anastomoses with the external malleolar and tarsal branches of the anterior tibial; (5) terminal branches, which pass down to the external malleolus, and anastomose with the malleolar and plantar arteries of the posterior tibial.

Collateral Circulation (Fig. 8).—When the *posterior tibial* artery is tied at its upper part—(*a*) By the communicating branch between the posterior tibial and peroneal (29); (*b*) muscular branches of the posterior tibial anastomosing with muscular branches of the peroneal; (*c*) malleolar branches (30) of the anterior tibial anastomosing with the anterior peroneal (28), and terminal branches of the peroneal (36), and calcanean branches of the posterior tibial; (*d*) the communicating branch of the dorsal artery of the foot (33), anastomosing directly with the external plantar (31) from the posterior tibial; (*e*) the tarsal and the metatarsal branches of the dorsal artery of the foot, anastomosing

at the sides of the foot with the external (31) and internal (32) plantar arteries; (*f*) the perforating branches of the plantar arch anastomosing with branches of the metatarsal branch of dorsal artery. When the artery is ligatured at the lower part, the collateral circulation is carried on by anastomoses 2 to 6 (inclusive) of above. When the *peroneal* artery is tied, the collateral circulation will be carried on chiefly by the first three anastomoses enumerated above.

ANTERIOR TIBIAL ARTERY.

Origin.—From the bifurcation of the popliteal artery at the lower border of the popliteus muscle. **Extent.**—From its point of origin to the middle of the ankle joint, where it becomes the dorsal artery of the foot. **Course.**—It passes forwards between the two heads of the tibialis posticus, and then through the opening *above* the upper part of the interosseous membrane, and then passes downwards obliquely towards the ankle joint. Its course may be indicated by a line drawn from the inner side of the head of the fibula to a point midway between the internal and external malleoli. In its upper third the vessel lies deeply, in its lower two-thirds it is more superficial. **Relations.**—It is covered by—(1) The skin; (2) superficial fascia; (3) deep fascia; (4) the anterior tibial nerve crosses it once or twice; (5) near the ankle it is crossed by the tendon of the extensor proprius hallucis. It is also overlapped by the fleshy bellies of the contiguous muscles. On its inner side—(1) The tibialis anticus; (2) near the ankle the extensor proprius hallucis. On its outer side—(1) The anterior tibial nerve, at the upper part of the vessel; (2) extensor

longus digitorum for about two inches; (3) the extensor proprius hallucis; (4) anterior tibial nerve, at the lower end. It rests on—(1) The interosseous membrane in its upper two-thirds; (2) the tibia, in its lower third; (3) The anterior ligament of the ankle joint. The anterior tibial nerve, one of the three terminal branches of the external popliteal, winds round below the head of the fibula, between the bone and the peroneus longus, lying in close relation with the bursa between the tendon of the biceps and the external lateral ligament, and then passes beneath or through the extensor longus digitorum to join the vessel.

Like the radial, which it resembles in many points, it may be tied in three places—(1) In its upper third, where it lies between the tibialis anticus and the extensor longus digitorum, resting on the interosseous membrane with its nerve to its outer side. (2) In its middle third, where it lies between the tibialis anticus and the extensor proprius hallucis, and still resting on the interosseous membrane with its nerve probably in front or to its inner side. (3) At its lower third, where it lies between the same two tendons, but is now resting on the tibia with its nerve once more to its outer side. The patient should be recumbent, as usual, his knee should be flexed, so that the sole of his foot rests flat on the operating table; pillows, or some other support should be placed in the angle formed by the leg and thigh, and the whole steadied by an assistant. In the deeper part of the dissection the ankle must be flexed freely to relax the muscles on the anterior aspect, and an assistant should be prepared to keep them apart by broad copper spatulæ at the upper or fleshy part of the leg, but in the lower or tendinous part blunt hooks may

be substituted for the spatulæ. The **Surgeon** stands in front and to the outer side of the limb.

(1) **In the Upper Third.**—To tie the vessel in its upper third an **incision** four or five inches long should be made in the line of the vessel, or crossing it rather obliquely downwards and inwards, along the outer margin of the tibialis anticus muscle, beginning one inch below the head of the fibula. Divide the skin and fascia, and expose the muscular aponeurosis. The inter-muscular septum between the tibialis anticus and the extensor communis digitorum (the long extensor of the great toe, not arising so high up on the fibula as this muscle) is next to be found and divided to the same extent as the superficial incision; great care is necessary lest the septum between the common extensor and the peroneus longus be opened instead of this one, and so the operator be led away from the artery. To prevent such a mistake, it will be well to bear in mind that the septum between the tibialis anticus and the common extensor is very *weak*, so that the two muscles are very readily separated; while the septum between the common extensor and the peroneus longus is very *strong* so that these muscles are separated with difficulty (Fig. 11). This is all the more important to remember, because the common extensor is very narrow above, and the operator is very apt, therefore, to open the septum between it and the peroneus longus. The ankle being flexed the two muscles — tibialis anticus and the extensor communis digitorum—are then separated and held aside with copper spatulæ, and the artery is then found lying on the interosseous membrane, with the anterior tibial nerve to its outer side. It is separated from its venæ comites, and its sheath opened and the

vessel cleared, and the ligature passed from the outer side. It is rarely, if ever, tied at its upper part in the living body, except for a wound, which is then, of course, taken as the guide to the vessel. Were it, however, considered necessary to do so, make the patient throw the tibialis anticus into action by flexing the ankle or inverting the foot before he is put under an anæsthetic, and mark its outer border. It is better in making the skin incisions to make them slightly oblique downwards and inwards, as it will then be easier to find the septum between the anticus and the extensor communis digitorum. The breadth of the muscle in an ordinary-sized individual may be regarded roughly as two finger breadths.

(2) **In the Middle Third.**—The steps of this operation resemble very closely those of the previous one. The **incision** need not be quite so long, nor so far from the anterior border of the tibia and when the deep fascia is opened take the tibialis anticus as the **guide.** Flex the ankle and separate the flexor proprius hallucis from the tibialis anticus when the vessel will be exposed resting on the interosseous membrane. Separate it from its venæ comites and anterior tibial nerve and ligature *secundum artem.*

(3) **In the Lower Third.**—The vessel is more easily reached in this situation as the bulk and depth of the muscles are much diminished. An **incision** should be made in the line of the vessel two inches long, about three quarters of an inch from the anterior edge of the tibia upon the outer side of the tendon of the tibialis anticus, and parallel with it; at this point the tibialis anticus is much narrower than it is at the upper part of the leg, and the extensor proprius hallucis lies to the

outer side of the artery. At this point, therefore, the artery lies between the tendons of the tibialis anticus and the extensor proprius hallucis, with the nerve to its outer side, and rests on the lower end of the tibia. The steps of the operation are similar to those described above. When the tendons are exposed flex the ankle and with blunt hooks hold them apart while the vessel is separated from the surrounding structures and ligatured.

Branches.—(1) The anterior tibial recurrent; (2) muscular; (3) internal malleolar; (4) external malleolar, which is the largest, and anastomoses with the anterior peroneal artery.

Collateral Circulation.—For this, see anastomoses, from three to six, inclusive, in 'collateral circulation' under the posterior tibial artery.

Dorsalis Pedis Artery.—**Origin.**—It is the direct continuation of the anterior tibial artery. **Extent.**—From the centre of the instep, beneath the anterior annular ligament, to the base of the metatarsal bone of the great toe, where it divides into the communicating branch to the sole of the foot and the dorsal artery of the great toe. **Course.**—Its course is from the centre of the instep to the cleft between the first two toes. **Relations.**—It is simply covered by the integumentary structures, and crossed near its point of bifurcation by the innermost tendon of the extensor brevis digitorum which may be taken as the **guide** to the vessel. It lies between the tendons of the extensor proprius hallucis and the extensor communis digitorum, and has the anterior tibial nerve to its outer side. It rests on the bones of the tarsus and their dorsal ligaments. It may be tied in the upper part of its course by an incision

an inch and a-half long, in the line of the vessel, on the outer side of, and parallel with the tendon of the extensor proprius hallucis. To reach the vessel it is only necessary to cut through the skin, superficial, and deep fascia.

Branches.—(1) Tarsal, (2) Metatarsal, (3) Communicating, (4) Dorsalis hallucis.

Collateral Circulation.—See anastomoses, four to six inclusive, under posterior tibial artery.

The External Plantar artery and Plantar Arch.—The course of this vessel may be mapped out on the sole of the foot as follows:—It begins at the lower part of the internal lateral ligament, behind the internal malleolus, and runs forwards and outwards, taking a slightly arched course, with the convexity outwards, to the base of the fourth intermetatarsal space; this forms its superficial part, and it is covered by the superficial structures and the first layer of muscles of the foot. From this point its course is deeper: it turns round the outer border of the accessorius, and runs forwards and inwards to the posterior part of the first interosseous space forming the plantar arch, lying upon the interossei and the bases of the metatarsal bones. The arch is completed by the communicating branch from the dorsalis pedis, and is covered by the first three layers of muscles of the sole of the foot.

In regard to **wounds** of this arch the same principles of treatment must be adopted as in wounds of the palmar arches. The vessel is deep—the fascia over it is dense,—the tendons and muscles are numerous and important; a large scar on the sole of the foot is a serious thing, and therefore before lightly undertaking the operation of tying the vessel at the bleeding point

these facts must be duly weighed for the patient's sake —for it is not a question of mere operative dexterity. first see that the vessel is more than *wounded*, make sure it is completely divided; if this is not sufficient, then second use a graduated compress properly applied, combined with flexion of the knee; if even yet it does not stop, probably the best plan is third to tie the superficial femoral. This at first sight may seem far fetched, but it is not really so. The ligature of the superficial femoral is not surely such a serious thing as ligature of *at least three* vessels below the calf, probably more, and even then a considerable risk of failure: while ligature of the single vessel in the thigh will almost certainly be sufficient. At the same time it should only be done when everything else has failed. Fourth just as in the hand, the plantar arch may be ligatured directly from the dorsum of the foot after removal of a part of one or other of the metatarsal bones overlying the vessel (DELORME).

CHAPTER XII.

AMPUTATIONS—INSTRUMENTS.

1. **Means to Command Hæmorrhage** DURING THE OPERATION, as (*a*) **Thumbs** of a trustworthy assistant, *e.g.* on the femoral artery as it lies on the ilio-pectineal eminence at the pelvic brim, in amputation of hip; the thumb of an assistant, or a **padded key** (the ring of the key is to be wrapped round with a strip of lint and used to press the artery, while the other end is well padded to prevent it injuring the assistant's hand), or SPENCE'S **special compressor,** to compress the subclavian against the first rib in amputation or excision of the shoulder joint. (*b*) LISTER'S **bloodless plan,** of first emptying the limb of blood by simply elevating it for about a minute, with or without rubbing, in the direction of the venous flow, and then applying Esmarch's elastic band or Petit's tourniquet without the pad. By this means he has shown that not only is the outflow through the veins increased, by the action of gravity, but that the inflow is also diminished on account of the contraction of the arterial walls. Petit's tourniquet with the pad alone, as it was formerly used, compresses both the main artery and the smaller vessels very effectually; a disadvantage is that it also arrests the flow of blood in the superficial veins, which are thus soon filled and bleed

a good deal during the early stages of the operation. (*c*) ESMARCH'S **bloodless plan.**—He applies a broad elastic bandage, spirally, from the distal extremity of the limb to be operated upon to the point at which the elastic band or tourniquet is to be applied; after applying the tourniquet he removes the broad bandage. By this means the limb is squeezed absolutely bloodless and remains so during the whole operation. Several **objections** have been urged against this plan. (1) It is said to predispose to reactionary hæmorrhage, probably from some injury to the vaso-constrictor or the vaso-dilator nerves, so that the vessels do not contract and retract as they otherwise would, and as there is absolutely no bleeding during the operation they cannot be seen and secured so well as in other methods. Again, one of the essential conditions for the natural arrest of hæmorrhage is absent, viz., blood, so that the small vessels have not an opportunity to seal themselves during the progress of the operation. (2) In cases of putrid sores, or soft vascular malignant growths, it is not advisable to force the noxious products further up the limb. (3) Where the elastic tourniquet is used it is impossible to loosen it *a little*, so as to let just enough blood down to make the open vessels visible, and give the smaller ones an opportunity of being plugged naturally by blood clot. With plenty of assistants this is no great disadvantage, but in operating single-handed it would be a serious inconvenience to the Surgeon, and risk to the patient from loss of an unnecessary amount of blood. Screw tourniquets, such as Petit's, have not this disadvantage, as they can be slackened or tightened at will.

2. **Straight Bistouries,** narrow and broad—narrow

bladed, for example, in amputation of the phalanges of the fingers, and metatarsals of fingers and toes.

3. **Scalpels,** not too broad bladed.

4. **Cutting Pliers,** of various shapes, to be used in cases where the bone has splintered during sawing, and in cases where it may be deemed expedient to remove the heads of the metacarpal bones. In using the pliers the *flat* side is to be placed next the part to be preserved.

5. **Amputating Knives** of various lengths. If for transfixion, their length should be from one and a-half to twice the diameter of the part to be amputated. Specially shaped knives are made for the circular method, although it is not by any means necessary to use them, as an ordinary transfixion knife does perfectly well. The blade is of the same breadth throughout; it is not sharp pointed like a transfixion knife, and further it is slightly curved towards the point, the concave side of the curve, of course, being towards the edge of the knife. By means of this knife it is supposed that the operator can encircle the limb more easily. In making flaps by dissection, the skin and the subcutaneous fatty tissue must be raised as one layer, and in doing so the edge of the knife must always be directed *away from* the skin (just the opposite to the plan used in the dissecting room) and towards the part to be removed. By this means we avoid cutting the small vessels in the subcutaneous fat that go to nourish the skin, and are therefore less likely to cause sloughing. The skin itself must be cut at right angles to the surface to avoid undermining or shelving of the edge.

6. **Saws,** with strong broad blade, fine teeth properly set, and strong moveable back; also various other kinds

for special operations, as finger and metacarpal saws. In sawing the bone, previously cleared by the knife, place the *heel* of the saw on the bone, the blade being steadied by resting against the second joint of the left thumb, and then draw it with *firm* pressure towards you, in order to make a groove for it to run in and prevent it slipping about; after this use long, *light*, sweeping movements, the assistant in the mean time taking care to hold the bone in such a way that he does not lock the saw by raising it, nor snap it through before complete division by depressing it. In limbs with two bones of equal size they should be sawn through together; if of unequal size, the smaller should first be divided, and in the case of the femur the saw should be so manipulated that its posterior ridge *(linea aspera)* is divided before the rest of the bone is entirely sawn through.

7. **Ordinary Artery** and **Torsion Forceps.**

8. **Tenacula.**—Tenacula are required in some operations where the vessel cannot be secured by the ordinary forceps, as in cases when amputation is performed at a point where an artery is passing between two bones, and is apt to retract so much that it cannot be caught by ordinary methods, but must be secured by hooking up a little of the surrounding tissues with the artery. This is best done by a tenaculum plunged deeply through the tissues, and made to transfix the vessel which is then pulled forward, and the tissue, with the artery, tied under the tenaculum. Cases in point are met with in amputation just below the knee, where the *anterior tibial* artery comes through between the two bones; also in amputation just below the elbow joint, where the *posterior* interosseous artery passes through between the

radius and ulna. A like method of securing vessels may be necessary in amputating through chronically inflamed parts, or in places where the coats of the vessels are diseased, so that they cannot be pulled out sufficiently for the application of the ligature. A curved needle may also be used for a similar purpose.

9. **Lion Forceps.**—Used, for example, in SYME'S amputation at the ankle joint; and in CARDEN'S amputation at the knee.

10. **Periosteum Elevators** may be required in many amputations, *e.g.* hip, thumb, &c.

11. A good stock of WELLS'S or PÉAN'S **Forceps**, for the temporary arrest of hæmorrhage.

12. **Ligatures** and **Needles**, both for catgut and wire sutures. The needle for wire sutures has deep grooves near the eye, so that the wire may lie smoothly, and not obstruct the passage of the needle through the tissues.

13. **Scissors.**

14. **Retractors** of strong calico split at one end. In cases where there is but one bone, split it into two tails; where there are two bones it must be split into three tails. This method of retracting the tissues is sometimes used in the circular and in the combined flap and circular plans of amputation, but is not necessary in the pure flap amputations, the fingers of an assistant being all that is required. By this means, not only are the soft parts retracted, but are at the same time protected from the teeth of the saw, and from impregnation with sawdust.

15. **Dissecting Forceps.**

Assistants.—The number required will necessary vary much. The following is a fairly complete list:—

No. **one**, to administer chloroform.

No. **two**, to empty the limb of blood and command the main artery, take charge of the tourniquet, &c.

No. **three**, to attend to the flaps, to retract, &c.

No. **four**, to hold the part to be removed.

No. **five**, to assist operator, keeping the wound free of blood, and catching up small vessels with Wells's or Péan's forceps, and ligaturing the vessels as they are seized by operator.

No. **six**, to hand instruments to operator and his assistant.

No. **seven**, to wash sponges and supply them as required to No. five or operator.

In a well appointed hospital it is a simple matter to find plenty of assistants; but in many cases, *e.g.*, in country practice, it is impossible, and the operator has to do the work almost single-handed. Hereafter, in describing the different operations, to avoid unnecessary repetition, I will only mention the duties of the assistant who has charge of the leg, with an occasional reference to the one who has to look after the flaps.

DIFFERENT METHODS.

I. **Circular Method** (Benjamin Bell).—In the old and original circular method all the tissues were cut through at one level. This was before the days of tourniquet's or chloroform. From this crude origin there was a gradual progress up to the time when it may be said to have been perfected by Bell, and was from henceforth known as the '*triple incision.*' The integument being drawn up by an assistant, who grasps the limb with both hands, the operator divides the skin and fat by a single circular sweep of the knife; the skin and fatty tissue are then dissected

back as one layer for a distance equal to half the diameter of the limb, very much in the same way that one might turn up the cuff of one's coat. The muscles are next divided at the level of the retracted skin by another circular sweep of the knife, and retracted for a distance varying from one to two inches, according to the thickness of the limb; and lastly the bone is cleared and sawn as high up as possible. The name, 'triple incision,' was given to this method by Mr Hey, who also advised that the posterior muscles should be cut longer than the anterior, to compensate for their retraction, as they are cut further from their origin, and therefore retract more than the anterior. The *first* incision is through the skin and fat only; the *second*, through the muscles; and the *third*, round the bone to separate the muscles and clear it for the application of the saw. Advantages. (*a*) All the blood vessels are cut transversely, and are therefore more likely to contract and retract well and prevent unnecessary hæmorrhage: (*b*) in fleshy limbs it is specially good, as it prevents redundance of useless muscle; (*c*) the surface of the wound is smaller than in the flap method. Disadvantages. (*a*) The cicatrix is opposite the end of the bone and adherent to it; in the lower extremity this is a serious disadvantage, as the patient can never bear any part of the weight of the body upon it, and besides it causes a painful and tender stump. (*b*) It is a tedious and therefore a very painful operation; this, however, is of no consequence now, as the patient is anæsthetised.

II. Flap Method. By flaps, formed either by cutting from without inwards (*i.e.*, by dissection), or from within outwards (*i.e.*, by transfixion). The number, size, and position of the flaps vary much; the flap

furthest from the main artery is usually cut first. **Advantages.**—(*a*) It is more easily and rapidly performed as compared with the circular, and is therefore less painful to the patient; but this, as already stated, is of little consequence now-a-days. (*b*) It gives a good muscular cushion to cover the end of the bone; this advantage, however, is more fancied than real, for Surgeons are inclining to the belief that much muscular tissue in a stump is an unmixed evil. The muscular tissue atrophies and finally disappears, so that, from this point of view, the circular is as good as the flap. (*c*) At joints flap amputation is better than circular. **Disadvantages.**—(*a*) Many of the vessels are cut obliquely, and therefore do not retract and contract so much as they would were they cut transversely as in the circular method. (*b*) Previously it often failed to produce so good a stump as the circular method, on account of the irregular retraction of the different muscles. (*c*) The surface of the wound is larger than in the circular amputation.

Transfixion *versus* **Dissection.**—**Transfixion**.—In muscular limbs the flaps are apt to be redundant, heavy, and easily displaced; further, the muscles 'start,' and this delays primary union, and is very painful to the patient. It is more easily and speedily performed, but more difficult to form a well-shaped flap. When there is much muscular tissue it has to be tucked in to allow the skin surfaces to meet; this causes tension, gaping of the wound, giving way of the stitches, and many other evils.

Dissection.—The flaps can be shaped better, and one can better choose the relative proportions of muscle and skin entering into the flaps. It is less easy to perform

and takes longer time. In many places it is impossible to transfix, as the bone is too thinly covered, *e.g.*, anterior aspect of the leg, and the posterior aspect of the forearm; in these situations the flaps must be made by dissection. In cases of smash requiring amputation the flaps must be shaped by dissection, otherwise the tendons and muscles being loosed by the injury, yield before the knife and are dragged out.

The best form of flap is one made by dissection, composed of the cutaneous and subcutaneous tissues, with, if necessary, a little muscular tissue taken up towards its base to prevent sloughing of the skin flap.

III. **Combination Methods** (*flap and circular*).—(*a*).—**Modified Circular** (Syme).—Two semi-lunar incisions are made through the integuments, which are then dissected and drawn up for two inches, and the muscles divided by a circular incision on a level with the retracted skin, the muscles on the posterior aspect being divided somewhat lower down than those on the anterior aspect. The soft parts are then forcibly retracted, and the bone cleared and sawn higher up.

The only difference between the 'modified circular of Syme, and the 'triple incision' of Bell, consists in the mode of dealing with the skin. The 'modified circular' is specially useful when amputating through cone-shaped parts, as, for example, just below the calf. In that position, were the ordinary circular method used, it would be impossible to retract the skin sufficiently without splitting it; but the modified circular renders its retraction easy. In the upper extremity also it has the great advantage of giving the longest possible stump; the fact that the scar is opposite the end of the bone, is not such a serious objection in the upper extremity as

it is in the lower. It is also useful in amputations through the fleshy parts of the thigh, and in operations below the knee.

(*b*) **Teal's Method** *(by long and short antero-posterior rectangular flaps).*—The long flap is folded over the end of the bone, and should not contain the large blood vessels and nerves of the limb; and its length and its breadth should be each equal to one-half the circumference of the limb. The short posterior flap should only be one-fourth the length of the long one, and should contain the large blood vessels and nerves. Whether, therefore, the short flap is anterior or posterior will depend on the position of the large blood vessels and nerves, *e.g.*, at the ankle the short one will be posterior, while at the wrist it will be anterior. This method is chiefly used at the ankle and immediately above the knee. The **advantages** claimed for this method are—(1) The bone is well covered by sound tissue; (2) The cicatrix is situated high up on the posterior aspect; (3) It provides a dependent opening for the escape of discharges; (4) The patient can bear a considerable part of his weight on the end of the stump.

Its **disadvantages** are—(1) The great length of the flaps. Because of this the bone must be sawn higher up than in many other methods of amputation, *e.g.*, Syme's modified circular, and one would therefore be guilty of the serious error of removing more of the sound limb than is absolutely necessary, thus giving a less useful stump, as well as increasing the risk of the operation, since the nearer we approach the trunk, the more fatal do such operations become. This is very marked at parts where the limb at the point of section is particularly fleshy; when the limb is spare this disadvantage is

not so marked. (2) The *square* form of the flaps. This necessitates much time and great pains to make them fit well. (3) The anterior flap is doubled upon itself, and there is, therefore, great risk of impairing its vitality. (4) In amputating for malignant disease there is greater risk of recurrence in the long flap than in two shorter ones, the bones being divided at the same level. (5) So also in cases of great injury to the soft parts this method would be impracticable, as it would necessitate section of the bone high up. (6) Should the flaps fail to unite by the first intention, the heavy anterior flap will give rise to considerable trouble in the after treatment. (7) The cut surface is extensive.

(*c*) Spence's Method.—By a long anterior flap; but the flap is *not doubled upon itself*, nor does it require to be so *long* as in Teal's method; it simply folds loosely over the posterior segment of the stump, and, when healed, the cicatrix is on the posterior aspect. Its breadth should be fully one-half the circumference of the limb, and its free end gently *rounded*. A flap four inches in length will be sufficient for a limb twelve inches in circumference. On the posterior aspect the soft parts are divided obliquely towards the bone, beginning two inches lower than the level of the base of the anterior flap. The whole of the soft parts are then retracted, and the bone is sawn two inches higher up than the base of the flaps. This method is almost restricted to the lower third of the thigh, and is specially valuable in muscular limbs.

The advantages of this plan over Teal's method, so far as regards the length of the stump at any rate, are more apparent than real. If Spence's *flap* is two inches shorter than Teal's, he saws the *bone* two inches higher

up than the base of the flap, whereas Teal saws the bone on a level with the base of the flaps. But Spence's is more easily performed, provides as good a covering to the bone, the cicatrix is in a good position, the wounded surface is less, and should it fail to heal by the first intention it is more manageable.

(*d*) **Carden's Method.** — A rounded anterior flap composed of skin and subcutaneous tissue only. Its form and position resembles very closely Spence's anterior flap. Before sawing the bone the soft parts are retracted a little; there is no posterior flap. This method is used principally at the knee joint in amputation through the bases of the condyles.

(*e*) **Lister's Method.**—It resembles Teal's somewhat, only Lister takes the flaps more equally from the anterior and posterior surfaces. His method has all the advantages of Teal's plan, without its disadvantages. The anterior flap is about two-thirds of the diameter of the limb at the point where the bone is to be sawn, and the posterior, half that length; as compared with Teal, there is less sacrifice of sound limb. The scar is situated behind, and there is a free exit for discharges. This method is best suited for amputation through the fleshy parts of the forearm, leg, and thigh. The flaps are made by dissection, and are chiefly composed of integumentary structures; if it be deemed necessary, however, some muscle may be taken up at the base of the anterior flap, to lessen the risk of sloughing. The posterior flap is composed entirely of the skin, subcutaneous tissue, and fat. The flaps are then raised and the muscles divided by a circular sweep of the knife and retracted for a distance equal to one quarter of the diameter of the limb and the bone

divided at this point. Should the retraction of the flaps prove difficult, it may be necessary to carry an incision upwards from the angle of the flaps to the point at which the bone is sawn, either on one or both sides—somewhat after the manner of Teal, only he makes the lateral incisions at the beginning of the operation. In the thigh it is found necessary to retract the muscles for a distance equal to the diameter of the limb. Further, in the lower thirds of the leg and forearm it is necessary to make the anterior flap equal in length to the diameter of the limb, in order to ensure a good covering for the bone, and at the same time make certain that the cicatrix shall be situated behind; the reason is, that the *bones* form a greater proportion of the thickness of the limb in these situations.

IV. **Oval Method.**—This plan is specially adapted for disarticulation of the fingers and toes, shoulder and hip. It is really a circular amputation with a straight incision up one side of the limb, with the angles, where the straight and the circular incisions meet, rounded off. When the straight incision is longer than usual, it is often called the 'racket-shaped' incision, which may be used, for example, in amputation of the metatarsal bone of the little toe.

SPECIAL POINTS IN REFERENCE TO AMPUTATION.

Whatever method may be adopted, the following objects must be clearly kept in mind:—(1) Use every possible endeavour to save the patient's life, and give him the most useful limb—or stump rather—afterwards. Mere 'brilliancy' is not to be thought of in amputating; in the eyes of most men, who are endowed with a fair amount of common sense, it is about one of

the worst qualifications a Surgeon could possibly have. A living brother-man is at your mercy, who probably has his bread to win, and not only that, but perhaps also is the sole support of a wife and children. It behoves a Surgeon therefore, beyond all things, to keep in mind the golden rule formulated by One who was at once the most successful Surgeon, the greatest Teacher, and the truest Man that ever lived—'Therefore, all things whatsoever ye would that men should do to *you*, do ye even so to *them*.'

(2) Provide a sufficient covering of healthy integumentary structures, with as little loose muscular tissue as possible. The total amount of flap length should be equal to one-and-a-half times the diameter of the limb, at the point where the bone is sawn. The nerves are cut short to avoid their being included in the cicatrix and causing a 'painful stump.' The flaps should, as a rule, be made by dissection, and the anterior is to be about twice the length of the posterior.

(3) The scar should be situated behind, and for this purpose the long anterior and the short posterior flaps are best suited, as the bones in the thigh and leg are situated nearer the front than the back. By this means the scar is better protected from pressure and injuries, and the patient may be able to bear a considerable part of the weight of his body upon the stump; further the flexors retract more than the extensors, and this will pull up the scar still further.

(4) Have a free exit for discharges. For this purpose the position of the longer flap will necessarily depend on the position of the limb during the after treatment. In the forearm the long flap should be taken from the dorsal surface—though, as a matter of fact, the *dorsal*

surface of the forearm corresponds to the *anterior* surface of the leg. Elsewhere it must come from the anterior surface, provided there is no special reason to the contrary, as in amputations of the foot, ankle, and wrist joint; in these situations the opportunity of getting a pad so fitted by nature for the purpose intended, having been previously accustomed to bear weight, outweighs every other consideration.

(5) Try to save as much of the sound limb as possible, for the nearer we approach the trunk the greater is the danger to the patient, and besides the longer the stump the more power will he possess over any artificial limb. The longest stumps can be obtained by the modified circular, or the equal antero-posterior flaps. This, however, must not be obtained at the expense of other equally important principles, as good drainage, posterior position of scar, &c.

CHAPTER XIII.

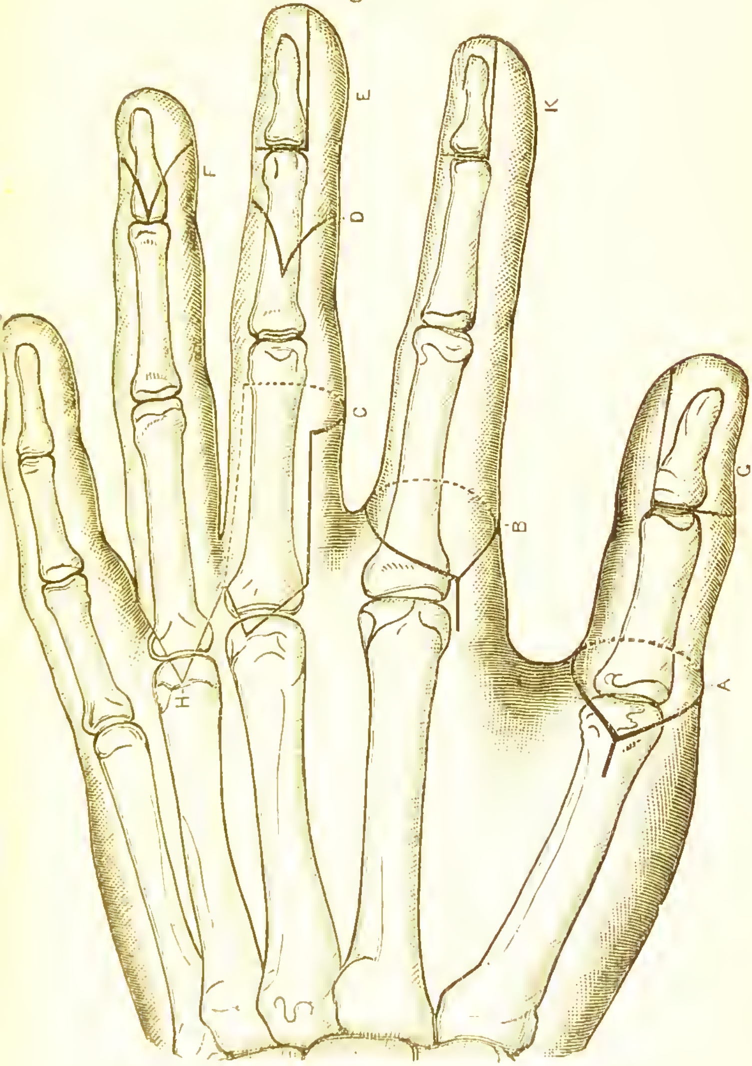
AMPUTATIONS OF THE UPPER EXTREMITY.

In regard to amputations of the thumb and fingers, the cardinal principles to be kept in mind are—(1) To keep up the full breadth of the hand, so that it may retain, as far as possible, its grasping and lifting powers; and, in order to do this, the heads of the metacarpal bones, at least of the second and third fingers, must not be interfered with, for a contracted hand is a weak hand, however pretty it may look. (2) To maintain the opposibility of the thumb or *any* remnant thereof. (3) That the ugliest and worst natural appendage is immensely superior, to its possessor, to the most ingenious and artistic artificial hand.

A TERMINAL PHALANX.

This amputation may be rendered necessary for injury or disease. A very common cause is the result of a bad whitlow. In whitlow, or abscess, of the pulp, the bone is very apt to necrose on account of the close connection between the fibrous tissue composing the pulp, and the fibrous periosteum immediately below. The base of the bone, however, usually escapes, because there the tendon of the long flexor is attached, and is surrounded by its sheath, and this, it would appear, protects the periosteum.

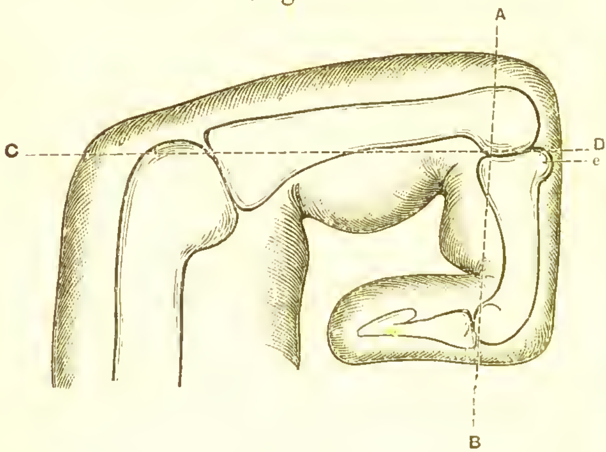
Fig. 12.



A. Amputation of the thumb at the metacarpo-phalangeal articulation by the 'oval' method. B. The same for the index finger. C. Chiene's method. D. Through a second phalanx. E. G. and K. Through a terminal phalanx, by a single palmar flap. F. Through a terminal phalanx, by double flap. H. Amputation of a finger by the double lateral flap.

1st Method—By Single Palmar Flap (Fig. 12, E.).—The hand should be emptied of blood by elevation, and an elastic tourniquet applied just above the wrist. It must then be held at a convenient height for the operator by an assistant, who flexes the elbow of the arm to be operated upon, places the forearm between his own left side and left arm, flexes the wrist, and places the hand in the prone position; the fingers on each side of the affected

Fig. 13.



A. B. and C. D. lines showing how to find the joints between the phalanges. e. Tubercle at the base of the second phalanx, which may be taken as the guide to that articulation.

one are to be well abducted and turned in towards the palm. The operator should stand facing the hand, and must be provided with a narrow bladed bistoury. He next grasps the tip of the phalanx to be removed between his forefinger and thumb and bends it to a right angle with the second phalanx, and then by a transverse sweep of the bistoury, from heel to point, opens the joint. The usual rule for finding the joint is

a good one—the joint is on a level with an imaginary line drawn along the middle of the lateral aspect of the second phalanx, when the finger is held as directed (Fig. 13, A. B.). The knife is then to be carried round the base of the phalanx, the first and second phalanges in the meantime being extended, while the terminal phalanx is still further flexed as the lateral ligaments are divided. When the knife has cleared the end of the bone the phalanx being amputated should be fully extended and a flap of sufficient length cut from the pulp. **Structures divided**—Skin, superficial fascia, digital vessels and nerves, extensor tendon, ligaments of the joint, and tendon of the flexor profundus digitorum. In many cases the removal of the whole phalanx, after the manner above described, is not called for, all that is required being simply to remove the necrosed piece of bone, the joint, as previously explained, often escaping. In this way the periosteum may form a new phalanx, and the finger be comparatively little the worse.

2nd Method—By Double Flaps (Fig. 12, F.).—The **assistant** in this case must hold the hand supinated, the finger to be operated upon fully extended, and the other fingers turned into the palm or held aside in any other convenient way. The **operator** standing as before, grasps the tip of the finger between his own forefinger and thumb, and, while keeping the last two phalanges extended, may flex it slightly at the carpo-metacarpal articulation. He then transfixes it as close to the bone as possible, taking care that the back of the knife is just a little way in front (*i.e.*, nearer the tip of the finger) of the crease in the skin corresponding to the joint. A flap of sufficient size is then cut, and is held out of the

way by the assistant. The phalanx is next to be over-extended, the joint opened, the knife passed through between the bones, and a small flap cut from the dorsal aspect. Provided he makes the palmar flap of sufficient length, the operator need not make a dorsal flap at all.

3rd Method.—By Circular Incision.—This plan may be adopted when there is not enough sound material left to form flaps. The finger may be conveniently held as in the first method, only it must be kept extended. The operator standing as before, makes a circular incision about half an inch nearer the tip of the finger than the joint. The structures are then to be reflected to the level of the articulation, the ligaments divided, and the bone removed.

THE SECOND PHALANGES.

The **second phalanges** may be amputated in exactly similar ways. An objection, however, to the amputation of a second phalanx is that we remove the entire attachments of the flexor sublimis and the flexor profundus tendons—the sublimis being attached to the sides of the second phalanges, and the profundus to the base of the terminal phalanx. The broad expansion, however, of the common extensor that covers the back of the first phalanx is left, and forms new attachments, and therefore the stump remains fixed in the extended position, being neither ornamental nor useful, but positively in the way. One might, however, on purely anatomical grounds, suppose that it would not be quite so useless, for into this same expansion are inserted the lumbricales (the so-called '*fiddler's muscles*'), and the interossei muscles. Now the lumbricales act as flexors of the first phalanges and extensors of the other two,

while the interossei also act as flexors of the same phalanges, in addition to their more evident actions of abduction and adduction. This is theoretical, and experience alone is competent to decide the question. In the case of a single finger, therefore, it has usually been the custom, in circumstances requiring the amputation of a second phalanx, to remove the whole finger; in cases, however, requiring the removal of two or more fingers, it would manifestly be better to leave the first phalanges. Probably, also, in the case of the index finger it had better be left to act as an opponent to the thumb, but on this point Surgeons are not agreed. No doubt, the amputation of a single finger, as usually performed, weakens the grasp of the hand considerably; but there is no reason why the *whole* of the first phalanx should be removed, its base might be preserved and this would leave the joint intact and at the same time keep up the full breadth of the hand. In regard to the second phalanx, however, a compromise has been suggested. The hand being held in the same position as in the first method for the removal of a terminal phalanx, the operator makes two short antero-posterior semi-lunar flaps (Fig. 12, D.). The dorsal flap is made by dissection, its length and breadth being each equal to one half the diameter of the finger. The dorsal flap being completed and retracted, the finger is then transfixed at the base of this flap, the knife passing in front of the phalanx, and a semi-lunar flap, equal in size to the posterior, cut from the palmar aspect. Both flaps are then retracted slightly, and the bone divided by the bone pliers at a point previously determined. The flaps, if preferred, may both be made by dissection from the lateral aspects of the phalanx.

In cases where the whole phalanx is removed, the tendons, both flexor and extensor, should be stitched to the periosteum of the remaining phalanx in the hope that they will form new attachments, and give a moveable and useful stump. The rule for finding the joint is the same as in the first phalanx, or the tubercle at the base of the second phalanx may be used as the guide (Fig. 13, e.).

AMPUTATION OF A WHOLE FINGER.

The means to command hæmorrhage, the duties of the assistant, and the position of the operator, are the same as in amputation of a terminal phalanx by the first method.

1st Method—The Oval Operation (Fig. 14).—This method has the advantage that it does not interfere with the palm. The bistoury is entered a little behind the head of the metacarpal bone, and after making a short median incision, passes obliquely round the root of the finger as far as the point of union of the web with the palm, and then across the palmar aspect of the finger in the crease of the skin at its root. Up to this point the knife has not been removed from the wound, but has been gradually laid on from point to heel; but to complete the oval the knife is removed, the left arm and hand of the Surgeon raised well out of the way, and the tip of the finger being amputated so held that now his thumb lies against its palmar aspect—when he commenced the operation his thumb lay on the dorsal aspect. He then re-enters the point of the knife at the end of the median incision on the dorsal aspect of the hand, and the remaining part of the oval is completed as on the other side. This plan is more convenient and neater

than the method usually adopted of re-entering the point of the knife on the palmar aspect and carrying it up from the palm to the dorsal aspect, completing the oval in that way; further by the plan above advocated one is more likely to make the two sides of the oval

Fig. 14.

Showing the shape of the wound in the 'oval' amputation, with the head of the metacarpal bone.

symmetrical. By the other plan, in making the second part of the incision, the Surgeon's right hand with the knife is over the back of the patient's hand. The skin oval is then to be drawn well back by an assistant, the

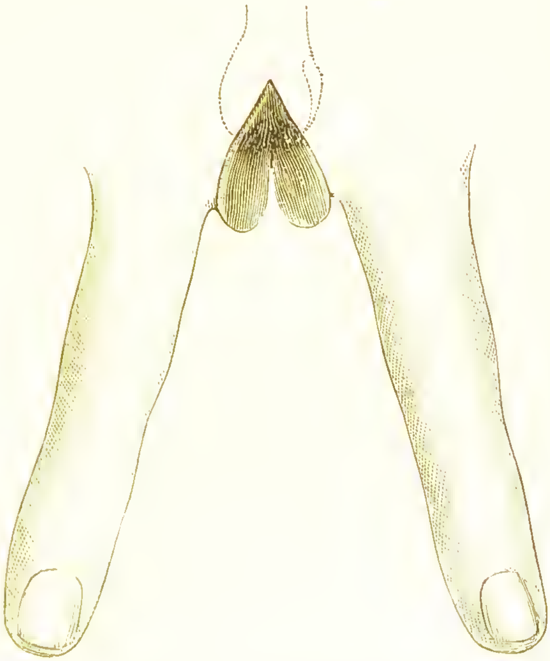
flexor tendons cut, and the joint opened by the division of the lateral ligament; the knife is next passed round the base of the bone, and the structures on the other side are divided from within outwards. In the performance of this operation it is of great importance to avoid any injury to the web between the fingers. This is best accomplished by cutting slightly on the base of the phalanx as the knife passes towards the palm, and in such a way that the centre of the lateral part of the oval may be slightly convex towards the tip of the finger. By doing so the head of the bone is better covered, and there is less cicatricial contraction of the hand afterwards.

Chief Structures Divided.—Skin, superficial fascia, digital vessels and nerves, the extensor tendon joined by the lumbrical and interossei muscles, the flexor tendons—sublimis and profundus—in their sheath.

2nd Method—By Lateral Flaps (Fig. 15).—Two equal lateral flaps are formed from the tissues at the base of the phalanx, the convexity of the flaps being directed towards the tip of the finger. The special advantage of this form is that it provides a free exit for the discharges, but has the disadvantage that it interferes with the palm. The **assistant** separates the adjoining fingers as before and pulls the integument on the back of the hand well up, and then the **operator**, standing in front of the hand, seizes the finger between his own forefinger and thumb and enters the point of the bistoury immediately over the head of the metacarpal bone and carries the incision 'laying on' the blade as he proceeds, in a convex sweep past the interdigital web and ends at a point just opposite the point at which he started. This forms one flap, and the other may be made in an exactly similar manner;

or, after having made the first flap, he may at once open into the joint, pass the knife round the base of the bone and cut the other flap from within outwards. The ligaments and the tendons, &c. being divided, the finger is removed.

Fig. 15.



Showing the shape of the wound in the amputation by lateral flaps, with the head of the metacarpal bone.

3rd Method.—By Single Palmar Flap (Fig. 12, C.).—(Professor Chiene).—In addition to the simplicity of this method, we believe that it more nearly approaches the ideal of what amputation of a finger should be than any other. It fulfils admirably the two essential conditions, viz.—(*a*) To keep up the full breadth of the hand,

and (*b*) to avoid the remotest approach to a cicatrix in the palm. Before, however, describing the operation, I propose to say a few words on the treatment of the heads of the metacarpal bones of the second and third fingers. It is usually admitted now-a-days that in those who labour *with their hands* ('*workmen*') they had better be left; but then there comes the difficulty of finding sufficient tissue to cover the head and fill up the ugly gap, and even when the wound is healed (often after tedious granulation), the cicatricial contraction leads to great deformity and much crippling of the hand. It was from considerations, such as these, we fancy, more than for any other reason, that in the past it has been so universally advised to remove the head of the metecarpal bone along with the finger. But what is the result? The arch is broken, its powerful connecting transverse ligament divided, the hand becomes squeezed up as if by an incubus it cannot shake off, its free motions are hampered, and its usefulness permanently damaged. Again, it is said that in those who do not labour with their hands ('*gentlemen*'), the head of the bone should be removed, chiefly for the sake of appearance in order to secure a taper and shapely hand. Such hands, no doubt, look very taper and shapely in *woodcuts*. But we do not think that the appearance of the hand is improved, and even if it were, the improved appearance is purchased at too big a price. The feeling and appearance of awkwardness which ever afterwards characterises the use of the hand (*e.g.*, in public speakers), will convince any one that even in 'gentlemen' the head of the bone should be left.

In Professor Chiene's method (Fig. 12, C), the hand is held in the usual manner, and the point of a sharp

bistoury is entered just over the metacarpo-phalangeal articulation, and carried for about *half way* round the lateral aspects of the root of the finger to be removed. From this point two lateral incisions are made along the sides of the finger parallel with its dorsal surface, and these are next joined by a transverse incision across the palmar aspect of the finger just below the crease between the first and second phalanges. This flap, which may or may not contain the long flexor tendons, is then held aside by an assistant; probably the tendons had better be cut off short at the base of the flap, and the finger is then cleared from its further connections and removed. The flap is then turned up and fixed to the edge of the dorsal wound by a few points of suture.

THE INDEX AND LITTLE FINGER.

In the case of the **index finger** (Fig. 12, B.), the oval incision, or the 'racket-shaped' modification, is to be preferred. The straight part of the incision is begun on the middle of the lateral aspect of the metacarpal bone and carried forwards to its head, and then the oval made round the root of the finger. This gives a single lateral linear cicatrix well away from the palm, and also out of sight. The **little finger** is treated in exactly the same way, the straight part of the incision being placed on the ulnar side. Mr BELL, however, in both cases advises the use of the ordinary lateral flap method, the only difference being that he makes a specially large flap on the free surface of each finger to fold over the end of the bone. In this way there is no cicatrix on the lateral aspects of the hand. As regards the **heads of the metacarpal bones** of the index and little finger

the usual rule is to cut them off obliquely, either with the bone forceps or a small saw, in order to avoid the square, step-like knob which would otherwise remain, and would probably get more than its own share of knocks. But again it is advised by some authorities that in the case of a 'workman' both should be left. The better plan is undoubtedly to remove part of the bone; it is cut off obliquely in such a way that the whole transverse breadth of the head is not removed. By this means the ligamentous connection joining the metacarpal bones of the index and little fingers to the other metacarpal bones is not divided. The **structures divided** are almost the same as in the other fingers. In the **index** finger, in addition, would be divided the tendon of the extensor indicis attached to the expansion over the first phalanx, with the dorsalis, and radialis indicis arteries. In the **little** finger, in addition to the ordinary structures, the extensor minimi digiti would be divided.

THE THUMB.

No rules can be laid down for amputation of the thumb. In all cases as little should be removed and as much left as possible, even to half a phalanx. Each of its different segments has a complete set of muscles to command it, and in this respect it differs from a finger; so that whatever is left will ultimately prove useful. In cases where it is absolutely necessary to remove a considerable part of one or more of its bones, it should, if possible, be done subperiosteally, because anything which is under the patient's control and opposible to the other digits, is of the greatest possible value. For the sake of practice on the dead body we will give a short

account of what may be styled the **classical** methods of amputating the thumb and its metacarpal bone.

(*a*) **The Flap or V-shaped Method.**—The most convenient position to hold the hand is one midway between pronation and supination, for then it may be pronated or supinated as required, the manipulations differing somewhat on the two sides; the fingers are to be held out of the way by the same assistant. The **surgeon** may most conveniently, I think, stand in front of the hand. He grasps the tip of the thumb, keeping it extended and slightly adducted, and clearly fixes in his own mind the position of the carpo-metacarpal articulation. **On the left side.**—The knife is entered on the dorsal aspect of the thumb about half an inch beyond the base of the metacarpal bone and then carried obliquely over its ulnar side till it divides the structures forming the web between the index finger and thumb, the point of division being rather nearer the thumb than the index finger. The hand is then supinated, and the thumb bent inwards towards the centre of the palm to relax the muscles forming the ball of the thumb, and the knife, without ever having been withdrawn from the wound, is made to transfix the ball passing close in front of the metacarpal bone, and its point brought out at the first incision at the base of the bone. The thumb is then extended and abducted to render the muscles tense, and the edge of the knife turned towards the skin and a flap cut from the muscles forming the ball, the line of the incision being made to correspond to the dorsal incision, so that when the disarticulation is completed, an elliptical and shapely wound remains. The dorsal flap should now be dissected back a little, the Surgeon himself holding the flap and giving the thumb to the

assistant in the meantime, or *vice versâ.* The thumb is now to be over-extended and the joint between it and the trapezium opened, the remaining structures divided, and the digit removed. In making the palmar flap, care must be taken not to lock the knife in the sesamoid bones; to avoid this, the direction of the blade must be altered slightly, by turning its edge a little towards the palm, till it has passed these bones. In the final stages of disarticulation, the edge of the knife must be kept close to the bone to avoid injury to the radial, and the radialis indicis arteries.

The right thumb is amputated in exactly a similar way, only in this case the Surgeon first makes the palmar flap by transfixion, and then the dorsal one by applying the heel of the knife to the web and cuts up to the end of the first incision, at the base of the metacarpal bone. He then completes the disarticulation as on the left side.

(*b*) **Oval Method—Racket-shaped Incision** (Fig. 12, A.).—This may be used either for the removal of the thumb at the metacarpo-phalangeal articulation or at the carpo-metacarpal. Begin the straight part of the incision at the base of the metacarpal bone, and carry it along its dorsal aspect (as the hand is held between pronation and supination) to within half an inch of the head: from this point an oval is carried round the root of the thumb. The two sides of the incision are then drawn apart by an assistant and the operation completed as in the former method.

Structures Divided.—In all the operations skin, superficial and deep fascia, and superficial vessels and nerves. **Muscles** cut in amputation through the **second** phalanx of the thumb—(1) Flexor longus

pollicis; and (2) extensor secundi internodii pollicis. Through the **first** phalanx—(1) Abductor pollicis; (2) flexor brevis pollicis; (3) adductor pollicis; and (4) extensor primi internodii pollicis, and the above list, of course, as well. Through the **metacarpal** bone—(1) Opponens pollicis; (2) extensor ossis metacarpi pollicis; (3) first dorsal interosseous, with, of course, the above two lists as well. So that in amputation through the **terminal** phalanx **two** muscles are divided; through the **first** phalanx **six** muscles; and through the **metacarpal** bone **nine** muscles. In amputation through the metacarpal bone the **arteries cut** are—(1) Princeps pollicis; and (2) the dorsales pollicis. The **arteries to be avoided** in the same operation are—(1) Radial artery, and (2) the radialis indicis.

Little need be said in regard to amputation of the metacarpal bones of the fingers. Should they require removal for injury no rules can be given. For disease any one may be dissected out by a single dorsal incision. Removal of both metacarpal bone and finger may be most conveniently performed by the 'racket-shaped' incision—a straight dorsal incision, and then encircling the root of the finger by an oval incision. It is advisable, where possible, not to remove the base of the metacarpal bone, as in this way we avoid opening up the carpal articulations. In removal of the **index** finger with its metacarpal bone the following **structures are divided**—skin, superficial fascia, &c.; and the following **muscles**—(1) Flexor carpi radialis; (2) extensor carpi radialis brevior; (3) flexor brevis pollicis; (4) 1st palmar interosseous; (5) 1st dorsal interosseous; (6) 2nd dorsal interosseous; (7) flexor sublimis digitorum; (8) extensor communis digitorum, with its lumbrical

muscle; (9) extensor indicis. **Arteries** divided—(1) Dorsalis indicis; (2) metacarpal (1st dorsal interosseous); (3) radialis indicis; (4) part, at least, of 1st digital from the superficial arch, and probably its communication with the corresponding interosseous from the deep arch.

CHAPTER XIV.

AMPUTATIONS OF THE UPPER EXTREMITY

(*Continued.*)

The Wrist.—The chief object in amputation at the wrist, in preference to higher up the arm, is not so much for the long stump as to preserve the movements of pronation and supination unimpaired. To insure this it is necessary that the inferior radio-ulnar articulation should be healthy. In all the different methods the arm should be emptied of blood by elevation, and the brachial artery secured by an elastic tourniquet or some other means. The **surgeon** should stand in front of the patient, while the **assistant** stands facing the surgeon and supporting the forearm at a convenient height. The **instruments** required are, a strong bladed and sharp pointed knife, artery forceps and ligatures, bone pliers, and a small saw.

1. **Teal's Method** (*Rectangular flaps*).—A long posterior flap, composed of skin and subcutaneous fatty tissue only, is raised from the back of the hand, its length and breadth being each equal to the circumference of the arm at the wrist joint; the anterior flap is to be one-fourth the length of the posterior, and, like it, to consist only of the integumentary structures. Both flaps are to be carefully raised, doing as little damage as

possible to the small subcutaneous vessels. Next, the extensor tendons are divided at the base of the posterior flap and the joint opened; in opening the joint remember its peculiar shape—convex, with the convexity upwards. Disarticulation being completed, both flaps are retracted, and the flexor muscles divided evenly at the base of the flaps. During healing, the elbow joint is flexed at a right angle and the forearm pronated, as the wound drains best in this position.

2. **Long Anterior and Short Posterior Flaps.**—The **assistant** holds the forearm pronated and pulls back the skin as tightly as possible. The **operator** grasps the hand, and, flexing the wrist, makes a semi-lunar incision on the dorsal aspect, from one styloid process to the other and raises a flap of skin and subcutaneous fat only (Bell)—the flap is to include the tendons of the back of the hand (Heath). In any case a flap is raised and the joint opened. The *palmar flap* may be made by dissection from the outside, before disarticulation, or dissected off the metacarpal bones from above downwards after disarticulation, having previously outlined its edges by a deep incision on each side of the metacarpus. It is almost impossible to make the anterior flap by transfixion on account of the transverse metacarpal arch, and the prominence formed by the pisiform bone and the hook of the unciform. The **vessels** requiring ligature are (1) the radial artery cut close to the radius; (2) the ulnar artery in the palmar flap; (3) sometimes the terminal twigs of the interosseous arteries. The styloid processes are to be cut off with the bone forceps, or the saw if preferred.

3. **The Modified Circular Method.**—The arm is held as in the previous operation, and two semi-lunar

incisions, beginning *one inch below* the styloid processes, are made through the skin, fat, and fascia only, and two short, equal, antero-posterior semi-lunar flaps raised. The flaps are next retracted a little above the level of the styloid processes, and the muscles divided by a circular sweep of the knife at that level, the assistant in the meantime keeping the different groups of muscles tense as the knife passes, *e.g.*, the anterior group by *over-extension (dorsiflexion)* the posterior group by extreme flexion. The late Mr SPENCE preferred this plan to all others, as, he said, by the ordinary flap method the styloid processes tended to project at the angles of the incision. During healing the forearm is to be kept between pronation and supination.

4. **By Long Palmar Flap.**—An assistant holds the arm supinated, and a large square flap, with the angles rounded off, is formed from the palm by dissection. The base of the flap should correspond to the *free edges* of the styloid processes, in order to give a good broad flap; and it should extend fully half-way down the palm, the full width being kept up throughout. It is composed of skin fat and fascia, and must be carefully dissected from the palm avoiding the prominences caused by the ridge of the trapezium and the hook of the unciform; but while avoiding these it is even of more importance to avoid button-holing the flap. Join the two ends of the anterior incision by a slightly curved incision across the dorsum through all the tissues down to the bones. After this flex the wrist joint forcibly, open it, and detach the hand by dividing the flexor tendons by a single sweep of the knife. The palmar flap contains—skin, superficial fascia, fat and palmar fascia with the cutaneous vessels and nerves, median and ulnar nerves,

superficial palmar arch and portions of the short muscles of the thumb and little finger. During healing the arm is to be supinated and laid on an elevated pillow, as in this position the wound drains best, and there is less tendency to displacement of the long palmar flap. But if more convenient the forearm may be kept midway between pronation and supination.

5. **Circular** ('*triple incision*').—An **assistant** holds the forearm and hand pronated, and pulls up the integuments as tightly as possible. The **surgeon** stands behind the arm (on the left side), grasps the fingers with his left hand, and makes a circular incision through the skin and subcutaneous fatty tissue, as close to the thenar and hypothenar eminences as possible. The tube of skin is then to be turned back by a few touches of the knife, to the level of the joint, and another circular incision made through the deep fascia and tendons at that level. The joint is then to be opened, the hand removed and the operation finished by sawing off the styloid processes, or snipping them off with the bone forceps.

6. Sometimes it may be necessary to make use of a **Single Long Dorsal Flap**, should the parts in front be hopelessly damaged. In amputation through the wrist joint the following are the **chief structures divided**.—(1) Integumentary structures; (2) **Muscles**—(*a*) Those towards the anterior aspect—tendons of the flexor carpi radialis, palmaris longus, flexor sublimis and profundus digitorum, flexor longus pollicis, flexor carpi ulnaris, (*b*) Those on the posterior or lateral aspect—Supinator longus, extensor ossis metacarpi pollicis, extensor primi internodii pollicis, extensores carpi radialis longior and brevior, extensor secundi internodii

pollicis, extensor communis digitorum, extensor minimi digiti, extensor indicis, and extensor carpi ulnaris; (3) **Vessels**—(*a*) Radial vessels, (*b*) ulnar vessels; (4) **Nerves**—(*a*) ulnar, (*b*) radial, (*c*) median; (5) **Ligaments of the wrist joint.**

LOWER THIRD OF THE FOREARM.

In amputating in this situation the objects are (1) To secure a long stump, and (2) To save the insertion of the pronator radii teres, and thus give the patient more power over any artificial substitute. The **assistant** had better stand in front of the limb, grasping the hand, and hold it either pronated or midway between pronation and supination, as most convenient for the operator. The arm should be at right angles to the trunk, and the elbow joint extended. The **instruments** necessary are A short amputating knife, artery forceps and ligatures, a saw, bone pliers, scissors, and dissecting forceps.

1. **Equal Antero-posterior Flaps.** The **Surgeon** should stand on the patient's right side of the limb to be removed, *i.e.* on the outer side of the right limb, but on the inner side of the left. The dorsal flap should be made first by dissection. The forearm being pronated, or else held with its dorsal surface towards the operator, he enters the knife a little to the palmar side of the ulna (supposing he is amputating the left arm; on the right arm he would begin by entering the knife a little to the palmar side of the radius) and marks out a broad dorsal flap, almost square, with the angles rounded off, consisting only of the integumentary structures. He then passes the knife in front of the bones a little below the base of this incision, and cuts an equal palmar flap from within outwards. In forming the anterior

flap the forearm should be supinated, and the operator must take care not to pass the knife between the two bones. Each flap should be equal in length to the antero-posterior diameter of the limb at the point of section of the bones, say from two to two and a half inches. The dorsal flap may be raised before or after transfixion, the surgeon taking hold of it with his left hand and freeing it with a few touches of the knife. Both flaps are then retracted by an assistant, and the bones cleared and divided about an inch higher up. The bones are cleared by a double edged catlin or other knife in a figure-of-eight-like sweep, and in doing this it is important not to allow the edge of the knife to be at all directed up the arm, lest the interosseous arteries (especially the anterior) be divided too high up, or split, and retract beyond reach. To avoid this the rule is always to keep the edge of the knife turned towards the part to be removed. As in all operations of this kind the large nerve trunks should be shortened with the scissors to prevent their being included in the cicatrix, causing 'painful stump.' As the bones are nearly of equal size at the point of section the usual practice is to divide them together. **Vessels requiring ligature** are —(1) Radial artery; (2) Ulnar artery; (3) Anterior interosseous; (4) Posterior interosseous; the radial and ulnar are found in the free end of the palmar flap. The objection to forming the anterior flap by transfixion is that the mass of muscles and tendons protrude beyond the skin; and more especially if the amputation is performed for injury, for then the loosened and injured tendons yield and are pulled out by the knife and leave a very ragged and unmanageable surface. Hence a better result is secured when both are made by dissec-

tion, and as already explained (see p. 164) it is better to make the posterior about twice the length of the anterior flap, with a little of the muscular structures taken up towards its base if deemed necessary; in this way the long flap is made to fold over the ends of the bones, the cicatrix is placed well to the front and less likely to be injured, and further, it drains better, as the limb is to be kept pronated during the healing process.

2. **By the Modified Circular Method.**—The different steps of this operation resemble very closely the previous one. Two equal antero-posterior semi-lunar flaps, consisting of skin and subcutaneous fatty tissue only, are made. The dorsal one is first raised with the same precautions as in the last operation to secure a good broad base to the flap. A similar flap is next raised from the front. Both flaps are then retracted and the muscles divided by a circular sweep of the knife; the bones are then cleared and divided about three-quarters of an inch higher up.

3. **By Teal's Method.**—Take the circumference of the limb at the point of section of the bones and mark out the two flaps according to the rules already laid down (see p. 166). Outline the sides of the long dorsal flap by incisions through the integument only, but at its apex carry the knife at once to the bones; this flap must consist of all the structures down to the bones and interosseous membrane. So likewise for the short anterior flap. During healing the forearm is pronated to keep the long anterior flap more easily in position, and at the same time provide a free exit for the discharges.

Mr C. HEATH suggests a modification of this method. In this the posterior flap consists only of the integu-

mentary structures until the level of the upper border of the posterior annular ligament is reached, when the knife is carried through everything to the bones. This is to avoid the difficulty experienced in dissecting the tendons from their grooves on the back of the radius and ulna, without damaging them. In Mr HEATH's plan there is also less difference between the length of the two flaps—his anterior being one-third the length of the dorsal, instead of one-fourth as in Mr TEAL's method.

4. As in other situations the **Circular 'Triple Incision'** may be used. The arm is held at right angles to the trunk, midway between pronation and supination, by an **assistant**, who also forcibly pulls up the integuments. The **operator** may conveniently stand behind the arm on the right side, and between the arm and the trunk on the left side; by so doing he is better able to retract the integumentary sheath, as he then can take hold of it with his left hand.

UPPER TWO-THIRDS OF THE FOREARM.

Amputation may be performed in this situation by—(1) **Equal Antero-Posterior Flaps, made by Transfixion,** or better, the dorsal one made by dissection and the anterior by transfixion. (2) **Long Posterior Flap,** chiefly composed of integumentary structures with a little muscular tissue taken up at its base, and an **anterior flap** of half the length. (3) The **Modified Circular** method. The same general principles must be applied in shaping the flaps, clearing and sawing the bones, &c., as in the lower third, so it is unnecessary to repeat them again. In making the anterior flap by transfixion, the knife should be

brought out rather sharply in order to keep up the full breadth of the flap, and cut the vessels and nerves transversely. It will thus be square-shaped rather than semi-lunar, and should be about three inches long. In transfixing, probably the best position to hold the forearm is one of supination. The structures divided in amputations through the forearm will vary slightly at the different levels. For instance, at the upper part the pronator radii teres and supinator brevis will be divided, while at the lower part they would not be included; and, near the wrist, the pronator quadratus and the extensor indicis would be cut, but not higher up. To save unnecessary repetition, the following may be taken as a fairly complete general list:—(1) Integumentary structures; (2) Muscles—(*a*) Pronator teres and flexor carpi radialis, (*b*) palmaris longus, (*c*) flexor sublimis digitorum, (*d*) flexor carpi ulnaris, (*e*) flexor profundus digitorum, (*f*) flexor longus pollicis, (*g*) supinator radii longus, (*h*) supinator brevis, (*i*) extensores carpi radialis longior et brevior, (*j*) extensor communis digitorum, (*k*) extensor minimi digiti, (*l*) extensor carpi ulnaris, (*m*) extensor ossis metacarpi pollicis, (*n*) extensor secundi internodii pollicis; (3) Vessels—(*a*) Radial (in the outer side of the anterior flap, and quite superficial), (*b*) ulnar (in the inner side of the anterior flap, and much deeper), (*c*) anterior interosseous, (*d*) posterior interosseous; (4) Nerves—correspond to and accompany the arteries—(*a*) Radial, (*b*) ulnar, (*c*) anterior interosseous, (*d*) posterior interosseous, (*e*) median; (5) Radius and ulna and interosseous membrane.

AMPUTATION THROUGH THE ELBOW JOINT.

1. This is usually accomplished by cutting a long flap from the anterior aspect of the joint and a small one posteriorly. It is seldom performed, because it is rarely possible to get sufficient sound texture to cover the large condyloid end of the humerus. The upper arm is to be well abducted and held by an assistant, the elbow joint flexed almost to a right angle, and at the same time the skin is to be well drawn up, especially when making the posterior incision. The Surgeon stands within the arm, when amputating, on the right side; but on the outside, when amputating, the left arm. The line of articulation of the elbow joint is oblique from without downwards and inwards, and therefore the knife must not be passed straight across the arm, or else the operator will find that the tissues will not cover up the internal condyle. The tissues being held well forward by the left hand, the operator then transfixes the limb in a line, extending from a little below the level of the external condyle of the humerus to a point at least an inch below that level on the inner side of the arm. On the left arm the point of the knife is entered at the outer end of this line, but in the right arm it is entered at its inner end. A broad flap, from two and a half to three inches in length, is then made, the knife being brought out sharply at the finish, to cut the vessels and nerves transversely, and give the end of the flap a somewhat square form. The flap is held up by an assistant, the forearm flexed, and the skin behind drawn tightly up, and the points of transfixion connected behind by a semi-lunar incision through the integumentary struc-

tures and probably also severing the connections of the radius. The ulna is then set free by division of its ligaments and the triceps muscle.

2. **The Circular Method** may also be used, but it is not so good as the flap. The forearm being held supinated, a circular incision is made through the superficial structures, about two inches below the internal condyle. The sheath of skin and fat and fascia is then retracted to the level of the articulation, the joint opened, the remaining structures divided, and the limb removed.

In this amputation the following are the **chief structures divided** — (1) Integumentary structures; (2) **Muscles**—(*a*) Biceps, (*b*) Brachialis anticus, (*c*) Pronator radii teres and flexors of the wrist and fingers, including the following muscles—flexor carpi radialis, palmaris longus, flexor sublimis digitorum, flexor carpi ulnaris, flexor profundus digitorum, and flexor longus pollicis, (*d*) Triceps and anconeus, (*e*) Supinator longus, (*f*) Supinator brevis, and (*g*) the following extensors of the wrist and fingers—Extensores carpi radialis longior and brevior, extensor communis digitorum, extensor minimi digiti, and extensor carpi ulnaris; (3) **Vessels**—(*a*) Radial artery, (*b*) Ulnar artery, (*c*) The common interosseous, or its branches, (*d*) Posterior ulnar recurrent, (*e*) The corresponding veins, and also the superficial veins of the forearm. (4) **Nerves**—(*a*) Median, (*b*) Ulnar, (*c*) Radial, (*d*) Anterior and posterior interosseous nerves; (5) **Ligaments** of the joint.

AMPUTATION THROUGH THE UPPER ARM.

This is said to be the simplest of all amputations, and may be effected with almost equal success by various methods.

1. **Equal Antero-Posterior Flaps by Transfixion.** By the use of equal flaps the bone can be divided at the lowest possible point, and the presence of a cicatrix at the end of the stump is not of so much consequence in the arm; and by making the flaps antero-posterior, associated groups of muscles are kept in separate flaps. The usual **instruments** are required, viz. :—An amputating knife, a saw, artery forceps, ligatures, and bone forceps. An **assistant** holds the arm at right angles to the trunk and rotated well outwards. The Brachial artery may be secured by the fingers of another assistant or by an elastic tourniquet; or, if the amputation is high up, the subclavian must be compressed against the first rib by the thumbs or a padded key. The brachial artery and the large nerves may be left in the flap the operator deems most convenient; the only point is to take care not to transfix them and sever the vessel transversely at last. The **Surgeon** is to stand within the arm, in amputating, on the left side, but on the outer side for the right arm. He next grasps the anterior muscles with his left hand, and holds them well forward, and then enters the knife with its point directed a little upwards, (*i.e.*, the point will be on a higher plane than the handle, which is to be slightly depressed), so as to secure a broad based flap, passes it as closely in front of the bone as possible, and then, by slightly raising the handle, makes the point emerge at a spot exactly opposite to that at which it entered. The knife is then carried downwards longitudinally for some distance by a slight sawing movement, so as to form a well-rounded flap from two-and-a-half to three inches in length, the skin being cut if possible longer than the muscles; for this purpose the knife must be gradually turned towards

the surface, but should be brought out sharply at last, so as to cut the vessels nerves and skin transversely. An assistant now lightly supports the flap, not retracting it at all, and the knife is then entered at the same point and carried behind the bone and made to emerge on the other side at the same incision, and a posterior flap cut of the same length and shape as the anterior. The assistant now retracts both flaps forcibly, and the bone is cleared by a circular sweep of the knife for about an inch above the angles of the incision, and the saw applied. In clearing the bone, be careful to cut the musculo-spiral nerve cleanly, as it lies in its groove on the posterior surface of the humerus. The large nerve trunks should be shortened with the scissors, and the artery, if cut obliquely, may be recut transversely. The **vessels** requiring ligature are—(1) The brachial artery, accompanied by the median nerve; (2) The inferior profunda accompanying the ulnar nerve; (3) The superior profunda accompanying the musculo-spiral nerve. Some operators make the anterior flap longer than the posterior. This, no doubt, has several advantages, but they are purchased at the expense of a shorter stump, and therefore it should not be performed.

2. **Circular Method.**—This may be used in very muscular limbs. The arm is held at right angles to the trunk, as usual, and the skin should be well drawn up during the first incision. This may either be intrusted to an assistant, or the operator himself may so stand that his left hand grasps the arm above the incision and draws up the skin at the same time. The operator now places his right foot well forward, bends both knees, and places his hand and wrist with the

knife, well round the arm, and then traverses the whole circumference of the arm at one sweep, the assistant who has charge of the arm rotating it, so as to meet the heel of the knife. He now seizes the integumentary tube with his left hand and frees it from the deep fascia by a few strokes of the knife, and turns it back like the cuff of a coat for two or three inches. The muscles and fascia are then divided by another circular sweep of the knife at the level of the retracted skin, and the bone cleared and sawn at a still higher level. In order to retract the tissues more easily and protect them from the saw, a two-tailed calico retractor may be used. As explained elsewhere the circular method is not to be recommended when amputating through cone-shaped limbs. In this case a far better method is—

3. **The Modified Circular.**—This has already been fully described elsewhere (see p. 165). In making the skin flaps the best rule is to cut just according to your cloth—anywhere and anyway, provided it gives you sufficient healthy tissue to cover the end of the bone.

4. **Teal's Method.**—This may be used in certain very exceptional cases. The long flap must be cut from the outer side of the arm, the short one from the inner side, and as usual containing the large vessels and nerves.

5. **By Equal Lateral Faps.**—The late Professor Spence strongly advocated this method when amputating at or near the middle of the arm, on account of the attachment of the deltoid muscle. When external and internal flaps are used, the external one folds over the end of the humerus when it is raised by the deltoid muscle; but if the flaps are antero-posterior in this

situation, when the deltoid raises the arm, the bone is liable to be projected at the external angle of the incision.

In a general way the **structures divided** in amputations through the upper arm are—(1) Integumentary coverings; (2) **Muscles**—(*a*) Biceps, (*b*) brachialis anticus, (*c*) triceps; (3) **Vessels**—(*a*) Brachial vessels, (*b*) superior profunda vessels, (*c*) basilic vein, (*d*) cephalic vein, (*e*) inferior profunda vessels; (4) **Nerves**—(*a*) Musculo-cutaneous (between the biceps and the brachialis anticus), (*b*) median (in close relation to and towards the inner side of the brachial vessels), (*c*) ulnar (accompanying the inferior profunda vessels), (*d*) musculo-spiral (accompanying the superior profunda vessels, (*e*) internal cutaneous close to the basilic vein. About the middle of the arm the brachial vessels are found on the *inner* side of the humerus; the inferior profunda vessels are found close to the brachial vessels, but a little further back; while the superior profunda vessels are found towards the posterior and outer aspect of the humerus.

AMPUTATION AT THE SHOULDER JOINT.

This may be rendered necessary by—(1) Disease of the joint and simple tumours; (2) malignant tumours; (3) injury. In cases where the Surgeon can choose his flaps, the best method to adopt is either that used by Baron LARREY, and associated with his name, or Mr SPENCE's method. Mr SPENCE's amputation is of especial value in cases where there is some doubt as to what is the best course to pursue—whether to excise or amputate. An incision is made as in the operation of excision, the joint examined, and, if found too much

disorganised to save, then it is a simple matter to transform it into his amputation. Of course, in the case of both malignant disease and injury, it is impossible to choose the flaps. In injury we must take them as best we can from the healthy or least injured tissues, and in malignant disease the usual practice is to form two *skin* flaps from the most healthy looking parts, taking care not to leave any muscular tissue in them. As in amputation at the hip joint, hæmorrhage is one of the most serious dangers, and, therefore, the principal methods of amputation aim at making the soft parts in the axilla, surrounding the axillary vessels, the last part to be cut through, the artery being previously compressed by the fingers of an assistant.

1. **Lateral Flaps of Nearly Equal Size** *(the 'oval' method).*—This was the method preferred by Larrey. It resembles almost exactly the amputation of a finger by the 'oval' method, as described in a previous chapter. The two sides are cut slightly convex, so that, when the operation is finished, the result is two almost precisely similar semi-lunar flaps meeting above at the acromion process, and below at the posterior fold of the axilla,—as the tissues on the inner side surrounding the vessels are so cut as to form part of the anterior flap. When the flaps are brought together a straight linear wound is the result. In this amputation two special **assistants** are required—**one**, standing above the shoulder, compresses the subclavian artery with his thumbs or a padded key, and holds himself in readiness to follow the knife behind the humerus and grasp the artery in the tissues at the inner side before they are divided. The **second** assistant places the patient in a proper position, by turning him partially over on

the sound side, and supports him in that position by pillows, and then holds the arm for the operator, who is to take his stand on the outer aspect of the limb. The arm being held slightly abducted, the operator thrusts the point of a strong, broad bistoury through all the tissues down to the bone immediately below the acromion process, and makes a straight incision about two inches in length, cutting on the outer aspect of the head and upper part of the neck of the humerus. From the end of this incision he carries other incisions in a curved direction on each side to the corresponding fold of the axilla. The two semilunar flaps thus marked out are next dissected up and held aside so as to expose the joint completely. The only vessel of any size divided at this stage of the operation is the posterior circumflex, and this should at once be secured by a pair of Wells's forceps. The assistant now adducts the arm in order to project and render tense the structures about the tuberosities rotating inwards and outwards, as may be required, while the operator divides the muscles attached to the tuberosities. The operator then opens the joint by dividing the capsular ligament, close to the anatomical neck of the humerus by a semi-circular sweep of the knife. The assistant again slightly abducts the arm, and pulls the head of the bone outwards from the glenoid cavity; the knife is then passed round behind it, dividing the remaining part of the capsule, and carried down the inner side of the humerus, close to the bone, followed by the thumbs of an assistant, who secures the vessel before the tissues are divided. The edge of the knife is now turned towards the surface, and the remaining tissues, between the end of the first and second incision, divided obliquely downwards and

inwards, so as to form part of the anterior flap. The **vessels** requiring ligature are—(1) The axillary artery; (2) probably the axillary vein; (3) branches of the circumflex vessels. The principal **advantages** of this method are—(1) The wound drains well; (2) its cut surface is as small as is consistent with efficient flap covering; (3) there is less risk of hæmorrhage during the operation than in some of the other methods.

2. **By Large External Flap** (Spence).—Hæmorrhage being provided against in the usual manner, an **assistant** slightly abducts the arm and rotates the humerus outwards. The **Surgeon** then cuts down upon the inner aspect of the head of the humerus, with a broad strong bistoury, immediately external to the coracoid process, and carries the incision down through the clavicular fibres of the deltoid and pectoralis major muscles as far as the insertion of the latter muscle which is to be divided. The incision is then carried across and deeply through the lower fibres of the deltoid as far as the posterior fold of the axilla. The course of the inner incision is next outlined from the end of the straight incision to the termination of the curved incision at the posterior border of the axilla, but must extend *through skin and fat only*. The deltoid muscle is next separated from the bone by the fingers alone, so as not to injure the trunk of the circumflex artery which enters its deep surface, and, having done so, the head and upper part of the humerus is fully exposed. The muscles about the head and capsular ligament are next divided by cutting directly down on the surgical neck of the humerus, the assistant in the mean time rotating the bone so as to bring the various muscles within reach of the knife.

The large external flap is then kept out of the way by the fingers of an assistant or a broad copper spatula, the knife is passed behind the bone, disarticulation completed, and the arm removed by dividing the remaining soft tissues on the axillary aspect, the axillary artery and vein being previously grasped by an assistant. The **advantages** of this method are—(1) The fulness and better form of stump left after healing; (2) the posterior circumflex artery is not divided except in its small terminal twigs in front; whereas, both in amputation by the large deltoid flap and the double flap methods, the trunk of the artery is divided in the early stages of the operation often giving rise to considerable hæmorrhage. In the case of the single deltoid flap the division of this vessel endangers its vitality, as the flap depends chiefly on it for its nourishment. (3) The great ease with which disarticulation can be accomplished, and especially the division of the tendon of the subscapularis muscle. (4) As already mentioned, it is further of great value in cases of doubt as to whether the joint should be excised or amputated. The first part of the incision is made use of to examine the joint, and then the Surgeon acts according to the condition in which he finds it.

3. **By Double Flap** (*antero-internal and postero-external*).—Both flaps may be made by cutting from within outwards, and are nearly of equal size and gently rounded. Three special **assistants** are required—**one** to take charge of the limb; a **second** to raise the deltoid flap; and a **third** to compress the subclavian artery against the first rib, and be prepared to follow the knife behind the humerus and grasp the inner flap, with the vessels, before its division. Should the

operation be performed on the right side, the operator stands before his patient; if on the left side he stands behind. The patient is brought close to the edge of the table, turned somewhat on the opposite side and supported in that position by pillows. The assistant then, standing on the opposite side of the table to the operator, slightly abducts the arm, to relax the deltoid muscle, and may at the same time also rotate the humerus a little inwards. The line of transfixion is from a point midway between the tip of the acromion and coracoid processes to another point within the posterior border of the axilla, well behind the root of the acromion and about an inch below the spine of the scapula. On the right side the operator enters the knife midway between the acromion and coracoid processes, passes it in front of the capsule of the joint, and makes it emerge at the posterior border of the axilla; on the left side he must enter the knife at the posterior border of the axilla, carry it across the front of the joint, and bring it out between the acromion and coracoid processes. In either case before entering the knife it is well to make a small incision about an inch in extent at the point where the knife is to be entered, to avoid cross-cutting the tissues with its heel. Supposing the right arm is to be removed and the patient is placed and the limb held as above indicated, the Surgeon enters the point of a long narrow-bladed transfixion knife midway between the acromion and the coracoid processes, passes it close in front of the capsule of the joint, and brings its out within the posterior fold of the axilla and cuts a large flap, three or four inches in length, and consisting chiefly of the deltoid muscle: the flap is then to be

raised by an assistant standing above the shoulder. The assistant who has charge of the arm then draws it downwards and forwards across the chest, while the Surgeon with the heel of the knife divides the capsular muscles and capsule close to and against the anatomical neck of the humerus, the assistant meanwhile rotating the bone so as to bring the various muscles within reach of the knife. The head of the bone being turned out of the glenoid cavity, the knife is carried round it and down the inner side of the shaft for about three inches with its edge kept close to the bone all the time, and is closely followed by the fingers of another assistant, who grasps the inner flap with the large vessels; when the artery is surely grasped, but not before, the operator cuts obliquely downwards and inwards, forming the internal flap. While this flap is being made the arm is slightly raised and abducted. The objections to this method are (1) To perform the operation satisfactorily we require the leverage of the humerus, but this is often smashed in cases requiring amputation. (2) It is often impossible to find sufficient healthy tissue to form the large external flap. (3) In cases requiring amputation for malignant disease transfixion is out of the question.

In cases where the tissues are thin, it may be necessary to form the deltoid flap by dissection; the line of the incision will correspond to that already given. In operating on the *right* side, the Surgeon, provided with a broad bistoury, stands below the shoulder, grasps the humerus with his left hand, brings it across the chest, and leaning over, commences his incision well behind the acromion, and about an inch below the spine of the scapula, near the posterior

fold of the axilla. The incision is carried downwards to the level of the insertion of the deltoid muscle, and then upwards and inwards to a point midway between the acromion and coracoid processes; as he makes the last half of the incision he should draw the arm away from the side. The flap thus marked out is then raised, the joint opened, and the inner flap cut in the usual way with a long narrow-bladed transfixion knife. Should he be amputating the *left* arm he must reverse the proceedings. He begins by drawing the arm away from the side, and commences the incision near the coracoid process, and ends at the posterior fold of the axilla, and as he nears the end of the incision he brings the arm across the chest.

4. **By Deltoid Flap.**—A large flap consisting nearly of the whole of the deltoid, is raised either by transfixion or dissection, and the different manipulations are nearly the same as in making the external flap in the previous method. The base of the flap will extend from the coracoid process to a little behind the most prominent point or angle of the acromion process. Should it be made by transfixion, the arm is to be held in the abducted position in the first instance. The flap is raised, and the assistant pushes the arm forcibly across the chest and rotates the humerus while the Surgeon severs the capsule and capsular muscles. The head being turned out of the glenoid cavity, the knife is passed round it and the structures in axilla divided, so as to form a short stump of tissues to meet the long deltoid flap which is laid over it. As in the other methods an assistant grasps the axillary on the inner side before the tissues are divided.

The objections to this plan are—(1) The large surface

of the wound; (2) the double line of cicatrix; (3) in many cases it would be impossible to get sufficient healthy tissue to form the large deltoid flap.

The principles adopted by JORDAN in amputation through the hip joint, might also, we think, in some cases be applied to the shoulder joint, especially in cases where the Surgeon is short-handed, so far as assistants are concerned. It would leave a longer stump than the other methods, and were it done sub-periosteally, a certain amount of power would be retained to control an artificial limb. The principles are (see Hip Joint Amputations) – (1) Amputation through the soft parts circularly low down; (2) Ligature all the blood vessels; and (3) dissect out the bone through an incision where it is least thickly covered, and where the blood vessels are small and few; in the shoulder the incision should therefore be along the anterior aspect of the joint and upper part of the shaft of the humerus.

Chief Structures Divided.—(1) The integumentary structures. (2) **Muscles**—(*a*) Deltoid, and the muscles in connection with the capsule of the joint, viz.—(*b*) supra-spinatus; (*c*) infra-spinatus; (*d*) teres minor; (*e*) subscapularis; (*f*) long head of triceps; muscles not attached to the capsule; (*g*) pectoralis major; (*h*) latissimus dorsi; (*i*) teres major; (*j*) coraco-brachialis; (*k*) biceps (both heads). The large **vessels** and **nerves** will be found on the inner flap, and consist of the axillary vessels and the cords of the brachial plexus; in addition to these the cephalic vein and the posterior circumflex artery are divided at some stage of the operation. The capsular, and coraco humeral ligaments, and the co to coracoid membrane are also cut through.

CHAPTER XV.

AMPUTATIONS OF THE LOWER EXTREMITY.

The Foot.—Just as in the hand, it is of primary importance to avoid all approach to a cicatrix on the sole. Therefore, whatever amputations are performed the flaps must always be taken from the plantar surface. Another point of importance is to leave the heads of the metatarsal bones. The foot is a tripod, resting on the heel, the ball of the great toe, and the ball of the little toe, and only in cases of absolute necessity should this tripod be interfered with in any way; for whether the two anterior rests are narrowed, as in removal of the central metatarsals, or any one of the three removed, the foot is rendered unstable. By a properly shaped boot and well padded stocking any inconvenience likely to result from the prominent heads of the first and fifth metatarsals is easily prevented. In amputations of the toes and metatarsal bones the best knife to use is a stout, straight, broad bistoury.

The Toes.—Partial amputation of the toes is but rarely performed, and only in the case of the great toe. In cases where any of the other toes are in a condition necessitating amputation it is always better to remove them at the metatarso-phalangeal articulation at once: because if any portion is left it is apt to be tilted upwards and is positively in the way. Even amputation

of the distal phalanx of the great toe is less frequently performed now than formerly. Formerly it was the custom to amputate this phalanx for exostosis—a form of bony growth frequently situated on the dorsal aspect of the distal phalanx of the great toe, and giving rise to much pain and discomfort from pressing up the nail. At the present time, however, the treatment adopted is to snip off the exostosis, being especially careful to destroy or remove all the cartilage covered area, and leave the toe alone. Should it, however, be necessary from other causes, such as injury, necrosis, onychia maligna, &c., to remove the **terminal phalanx**, this is best accomplished in a manner precisely similar to the analogous operations on the fingers by the formation of a flap from the plantar surface, the neighbouring toes being pulled to one side and flexed by an assistant by means of strips of narrow bandage.

THE GREAT TOE.

Amputation of the Great Toe **at the Metatarso-Phalangeal Articulation.**—This may be rendered necessary by injury or joint disease, and is best performed by the 'oval' or 'racket-shaped' forms of incision. It should be borne in mind that the metatarso-phalangeal articulations of all the toes are situated at least three quarters of an inch above the web. On account of the large size or the head of the metatarsal bone of the great toe the operator must take care to leave plenty of flap to cover it well. An **assistant** should hold the foot extended *(toes pointed)* in the first instance with the sole resting against, and the toes projecting over the end of the table; the neighbouring toes are to be held aside and flexed, as already indi-

cated, by narrow bits of bandage. The operator then enters the point of a stout bistoury over the middle line of the toe, half an inch above the joint, and carries it along the dorsum almost to the middle of the proximal phalanx, opposite which point the 'oval' part of the incision is carried round the toe. In doing so, the manipulations of the Surgeon and his assistant resemble those in the 'oval' amputation of a finger at the corresponding joint. By commencing the 'oval' at the point indicated we do not injure the web, and provide ample covering for the large head of the metatarsal bone, and there is thus less likelihood of the wound having to heal by tedious granulation and cicatricial contraction. The tissues over the end of the phalanx and joint are then to be cleared by passing the bistoury round with a short sawing movement, holding it parallel with the phalanx and well under control, and on no account to thrust its point too deeply in the sole, lest the trunk of the *anteria magna hallucis* be injured or the tissues unnecessarily punctured. After this the toe is to be over extended, the strong flexor tendons cut, and the joint opened from below; the toe is then to be twisted round as the knife divides the lateral ligaments and completes the disarticulation.

By making the straight part of the incision on the dorsum of the foot we avoid any scar on the lateral aspect, which might prove inconvenient being irritated and pressed on by the boot. The sesamoid bones may or may not be removed. Should the operator decide to leave them, it may be more convenient to open the joint from above, and divide the flexor tendons afterwards.

In the case of the other toes exactly the same

principles must be followed, and it is unnecessary, therefore, to go over them in detail. In all cases the oval method is to be preferred. Of course, as in the fingers, it can be done by two small lateral semi-lunar flaps, but this has the disadvantage of opening into the sole. Again, if preferred, in the case of the great and little toes (just as in the case of the index and little fingers), a specially large flap may be taken from the free side of each to fold over the end of the bones.

Amputation of the Great Toe with its Metatarsal Bone.—This should be done by the 'racket-shaped' incision. The foot is held as before, and the operator commences the incision on the dorsum, about half an inch behind the tarso-metatarsal articulation, and carries it along the dorsal aspect to near the metacarpo-phalangeal articulation, from which point the oval is made round the toe. The integuments are then to be separated from the bone on the inner side by applying the knife nearly parallel with the toes, and using it with a short sawing movement, its edge being kept close to the bone and well under control, especially near the tarso-metatarsal articulation; but lower down it need not be kept so close, as it is better to remove most of the short muscles of the toe and the sesamoid bones (HEATH). In the same way the strong interosseous ligament between the heads of the first and second metatarsal bones is divided, and the anterior extremity of the toe and the metatarsal bone cleared completely by sweeping the knife under the bone from without inwards. The toe is then forcibly drawn away from the others and the point of the knife passed between the metacarpal bones, with its edge directed upwards (*i.e.*, towards the anterior aspect of the leg) and the

ligaments of the tarso-metatarsal articulation divided close to the metatarsal bone of the great toe against which the edge of the knife is to be directed, lest the communicating branch of the dorsalis pedis artery, as it passes down to complete the plantar arch, be injured.

The straight part of the 'racket-shaped' incision may be made on the lateral aspect of the foot, the disadvantage of course being that the scar is apt to be irritated by the pressure of the boot. The method of removing the great toe and metatarsal bone as above described, by the 'oval' method, is not so rapid perhaps as the method of **lateral flap** by transfixion, but has the immense advantage of avoiding any scar in the sole. In the **flap** method, the Surgeon seizes the soft tissues on the inner side of the foot with his left hand and pulls them well inwards, and transfixes opposite the tarso-metatarsal articulation, and cuts a flap from the inner side as far as the middle of the first phalanx, keeping as close to the bone as possible. The assistant then pulls the soft tissues as far outwards as possible, so as to bring the incision over the space between the first and second metatarsal bones, and the Surgeon passes his knife between the bones through his former incision, cuts forwards right through the web, and then opens the tarso-metatarsal articulation as in the oval method, and completes the disarticulation. A similar flap may also be raised by dissection. As in the hand, it may be desirable not to open up the tarso-metatarsal articulations, but in the case of the great toe this is not of so much importance, as it has a synovial membrane all to itself; and, besides, it is usually in cases of partial amputation of this bone that trouble is apt to arise on account of wound of the com

municating branch of the dorsalis pedis artery. In partial amputations the bone should be divided obliquely, to avoid any unseemly and troublesome projection. A probable advantage is the preservation of the insertion of the peroneus longus and tibialis anticus muscles.

AMPUTATION OF THE **little toe with its metatarsal bone.**—This may be done by precisely the same methods —(1) The 'racket-shaped' incision, with the straight part of the incision on the dorsum of the foot—the best method: (2) Same incision with the straight part along the side of the foot—objection—the lateral scar; (3) External flap either by transfixion or dissection—very bad on account of the scar in the sole.

Partial amputation of the metacarpal bone of the little toe has fewer objections and more to recommend it than the corresponding operation on the great toe—(1) It has not a special synovial membrane to itself, but one common to it and the fourth metatarsal bone; (2) There is no special artery in danger of being wounded; (3) It preserves the insertion of the peroneus brevis and tertius tendons. Be careful, as usual, to divide the bone obliquely.

Chief structures divided in the foregoing amputations. In **all** the operations—Skin, superficial fascia, plantar fascia, digital vessels and nerves, and ligaments of the joints. The following **muscles** are divided in amputation of the **great toe at second phalanx, two** muscles—(1) Extensor proprius hallucis; (2) Flexor longus hallucis. **At first phalanx,** the above two muscles and in addition other **five**—(1) Abductor hallucis; (2) Flexor brevis hallucis; (3) Adductor hallucis; (4) Transversus pedis; (5) Extensor brevis digitorum.

AT THE **Tarso-metatarsal** ARTICULATION.—The above seven muscles and other **three**—(1) Tibialis anticus; (2) Peroneus longus; (3) First dorsal interosseous. So in amputation through the 2nd phalanx, **two** muscles are divided; through the 1st phalanx **seven** muscles; and both phalanges with the metatarsal, **ten** muscles. The **arteries divided** are—(1) Dorsalis hallucis; (2) The trunk or branches of the arteria magna hallucis. The **arteries** to be **avoided** are—(1) The communicating branch of the dorsalis pedis; (2) The plantar arch.

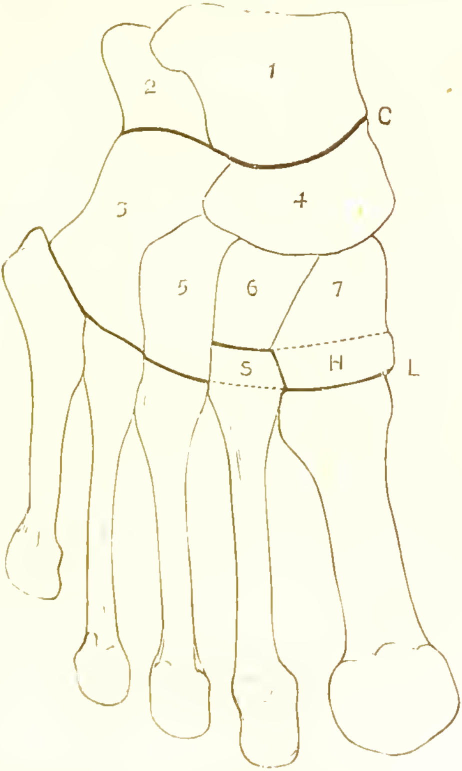
In amputation of the **little toe** with its metatarsal bone, the following **fourteen** muscles are divided. Into the **metatarsal** bone, *six* muscles—(1) Peroneus brevis; (2) Peroneus tertius; (3) Flexor brevis minimi digiti; (4) Transversus pedis; (5) Fourth dorsal interosseous; (6) Third plantar interosseous. Into the **first phalanx**, *four* muscles—(1) Abductor minimi digiti; (2) Flexor brevis minimi digiti; (3) Third plantar interosseous; (4) Fourth lumbricalis. Into the **second phalanx**, *two* muscles—(1) Extensor longus digitorum, (2) Flexor brevis digitorum. Into the **third phalanx**, *two* muscles; (1) Extensor longus digitorum; (2) Flexor longus digitorum.

TARSO-METATARSAL ARTICULATION.

Amputation of the Foot at the Tarto-Metatarsal Articulation (Fig. 16).—This is commonly called 'HEY'S amputation.' Disarticulation of the metatarsus is performed as far as the internal cuneiform bone, and then the projecting part of that bone sawn off (11). The disarticulation requires to be accomplished with care, as the end of the second metatarsal bone, in its articulation with the middle cuneiform, projects backwards between

the external and internal cuneiforms. Lisfranc's modification of this operation consists in the complete disarticulation of the tarsal bones, leaving the project-

Fig. 16.



Tarsus and Metatarsus.

1. Astragalus. 2. Os Calcis. 3. Cuboid. 4. Scaphoid. 5. External cuneiform. 6. Middle cuneiform. 7. Internal cuneiform. C. Line of Chopart's amputation. L. Line of Lisfranc's Amputation. S. Part of the second metatarsal removed by Skey. H. Part of the internal cuneiform removed by Hey.

Note the sigmoid curve formed by the line of Chopart's amputation; also the mortise formed by the three cuneiform bones, into which the base of the second metatarsal bone juts.

ing part of the internal cuneiform (L.). The reason for this modification is the supposed advantage gained by

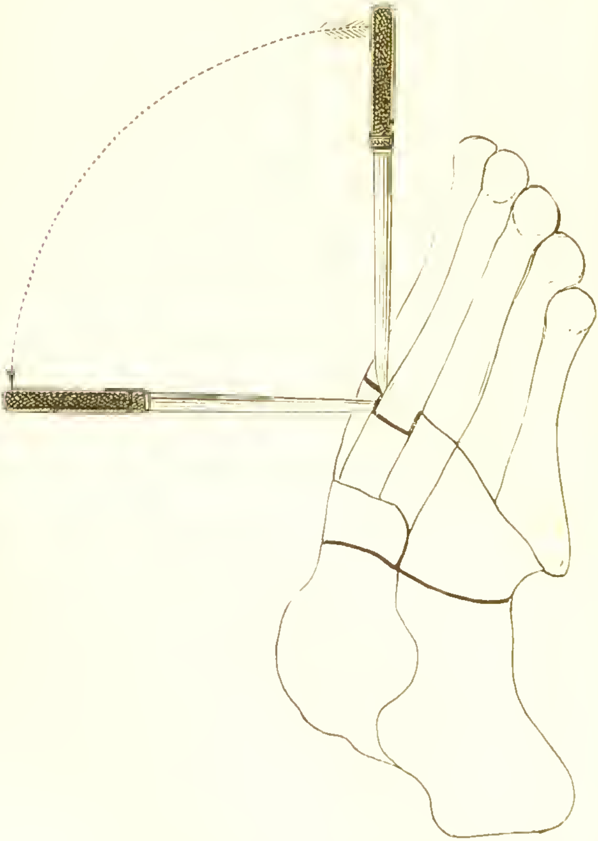
leaving the whole of the internal cuneiform bone, to which the tendons of both the tibialis anticus and the tibialis posticus are partially attached. But even in HEY'S operation the attachments of these muscles are not destroyed; for, although anatomists figure certain points on *bones* as the attachments of the muscles in question, yet it is found practically that they have extensive attachments to the deep ligamentous structures in their neighbourhood; so that this disadvantage, as urged against HEY'S operation, is more imaginary than real. Mr Skey removes the end of the second metatarsal bone, but does not interfere with the internal cuneiform.

The amputation may be performed in three ways:—In the **first**, the dorsal flap is made first, the bones disarticulated, and the plantar flap cut afterwards. In the **second**, the plantar flap is cut first, then the dorsal, and after this disarticulation performed. In the **third**, the dorsal flap is first made, as in the first method, the plantar flap is then shaped and dissected up as in the second method, and lastly the bones are disarticulated. In the **first** plan the leg is placed with the foot downwards, the ankle joint fully extended, and the **assistant** keeps the heel firmly fixed upon the table with the part of the foot to be removed overhanging its edge, and at the same time pulls up the skin. The **operator** then grasps the toes firmly, keeping the ankle joint well extended, and when the dorsal flap is outlined by the first incision, the assistant retracts it while the Surgeon frees it by a few touches of the knife; he then disarticulates, and finally forms the plantar flap. In the **second** form the **assistant** grasps the toes, and holds the foot at right angles to the leg with the heel firmly

pressed against the table, while the operator dissects up the plantar flap; the dorsal flap is next made as in first plan, the assistant holding the foot as there described, and the operator grasping the toes and extending the ankle joint. In the third plan, the foot is held as in the first stage of the first method (well extended and the Surgeon grasping the toes); it is next held as in the first stage of the second method (at right angles, and toes grasped by an assistant), and then disarticulation performed in a manner common to all the three. A strong, short, stout-backed, sharp-pointed, and not too broad-bladed bistoury is the best knife to use: the blade should be about four inches long. The guides for this operation are:—The projection formed by the fifth metatarsal bone on the outer side, and the tarso-metatarsal articulation of the great toe on the inner side, a groove corresponding to which may be felt by firm pressure, or, if this is indistinct, a point may be taken one inch in front of the tubercle of the scaphoid, which will indicate the articulation nearly enough for all practical purposes. In amputating by the first method the Surgeon seizes the toes with his left hand, extends the ankle joint well and places his forefinger and thumb on the points marking the line of the articulations—one well behind the projection of the fifth metatarsal bone, and the other over the metatarsal bone of the great toe. He then makes a semi-lunar incision, down to the bones, from one point to the other, forming a flap about an inch-and-a-half in length ('down nearly to the heads of the metatarsal bones,' Heath). The incision should commence and end fairly in the sole. The assistant then seizes the end of the flap to retract it, while the Surgeon by a few

sweeps of the knife dissects it up, taking care to keep the edge of the knife towards the bones. The articulations are then to be opened (Fig. 16): on the right side they are to be opened from the fifth inwards till

Fig. 17.



To show the method of freeing the second metatarsal bone from the mortise formed by the cuneiform bones.

the knife is arrested by the second metatarsal bone. the knife is then taken out and the articulation between the first metatarsal bone and the internal cuneiform

opened. The Surgeon then inserts the point of the knife obliquely between the bones, with its edge uppermost, and gradually raises it to the perpendicular (Fig. 17), and then presses firmly backwards between the bases of the first and second metatarsal bones and moves it gently backwards and forwards until he feels the strong interosseous ligament snap. The same may be done if necessary to the other side, and also between its base and the middle cuneiform, the toes at the same time being firmly depressed, and then, by giving a smart wrench, the disarticulation is completed. He then places his left thumb over the end of the disarticulated bones and dissects off a flap, consisting of the whole thickness of the tissues of the sole, and carries the dissection as far as the roots of the toes. From the layer of tissues thus dissected up, the operator shapes a neatly-rounded flap, longer on the inner than the outer side, by transfixing the centre and cutting towards each side, and so sloping the knife that the integumentary structures are cut longer than the muscles.

By the second method the plantar flap is cut first. A straight incision is carried from the two bony guides along each side of the foot, reaching nearly to the roots of the toes and the inner one longer than the outer; the two lines are then united in front by a gently curved incision, thus marking out a flap with well rounded angles. The flap is then raised, and at first should consist only of integumentary and fascial structures, but after the first inch, may include everything down to the bones. A dorsal flap is next to be made as in the previous method, the joints opened, and the bones disarticulated.

The **third** plan is probably the best. The dorsal flap is formed as in the *first* method, next the plantar is shaped and dissected up as at the beginning of the *second* method, and finally the bones are disarticulated. The **vessels requiring ligature** are—(1) The dorsalis pedis at the apex of the dorsal flap; (2) internal plantar; (3) external plantar; (4) numerous branches of the plantar arch. By making the short dorsal flap the cicatrix is placed rather on the front of the stump, and is thus opposed to the soft padding, whereas, were it on the dorsum, it might be injured by the pressure of the boot.

The **objections** to the tarso-metatarsal amputation (HEY, or LISFRANC), as thus described, are—(1) If practiced in a *diseased* foot, probably the other bones and joints will also be diseased and lead to a return of the mischief. (2) If for *accident*, it is far too elaborate and complicated, and more especially as the anterior parts of the foot are smashed, and, therefore, we have no advantage of leverage to assist in disarticulation: a simpler and better way being simply to dissect back a sufficient sole flap, and then saw the bones across at any convenient point, irrespective of articulations. This plan has further a special advantage, it may leave the front of the foot a little longer, which will thus form a more effective lever to oppose the tendo Achillis.

MEDIAN TARSAL ARTICULATION.

Chopart's Amputation (Fig. 16, C.).—This operation consists in the amputation of the foot at its transverse articulation—*i.e.*, the articulations between the astragalus and the scaphoid on the inner side, and the cuboid and the os calcis on the outer side; in other

words, the removal of that part of the foot that lies in front of the os calcis and astragalus. The shape of the articulation is alternately concave and convex—on the *inner* side it is *convex* forwards (due to the rounded head of the astragalus), but *concave* forwards on the *outer* side. The manipulations of the Surgeon, the duties of the assistant, and the three methods of raising the flaps, resemble very closely the corresponding stages of the previous operation, so that they need not be repeated in detail.

The **guides** for this operation are the tubercle of the scaphoid on the inner side, and a point one inch behind the projecting base of the fifth metatarsal bone on the outer side: or, in fat ankles, a point midway between the projecting base of the fifth metatarsal bone and the front of the external malleolus. The **knife** used by Chopart was about six inches long, half an inch broad, sharp pointed, and stout backed. Suppose the operation is to be performed by the **third** method, the **Surgeon** places his thumb and fore finger on the two bony points already indicated, and fully extends the ankle joint, and then makes a semi-lunar incision down to the bone, marking out a flap about an inch and a half in length, commencing and ending well in the sole. The **assistant** retracts this flap as the Surgeon frees it by a few touches of the knife. This being done, the assistant next seizes the toes and holds the foot at right angles to the leg and pressed firmly against the table, while the operator forms the plantar flap by cutting along the sides of the foot as far as the 'tread,' and joining the two side incisions by a gently curved one in front, but taking care that it leaves the flap much longer on the inner than the outer side, as the inner

edge of the foot is much deeper, and the flap somewhat square-shaped, with the angles well rounded. When the flap is fully dissected down, the foot is again extended, the bones disarticulated, and the operation completed by sawing off the projecting head of the astragalus and the articular surface of the os calcis.

The **objections** to this operation are—(1) If done for *disease* it leaves two bones of all others the most likely to be diseased. (2) If for *injury*, it is better to dissect up a sufficient flap from the sole and saw the bones at the most convenient point. (3) The muscles forming the tendo Achillis have nothing to counteract them and therefore draw up the heel, and the patient soon begins to walk on the front part of his stump, *i.e.*, on the cicatrix. For this reason it is advisable, in cases where this amputation is performed, to divide the tendo Achillis subcutaneously at the same time in order to equalize matters. SYME'S amputation at the ankle joint is to be preferred to either HEY or CHOPART in the case of disease of the bones, and for CHOPART in almost every condition.

Chief Structures Divided IN THE TWO PRECEDING OPERATIONS.—(1) The integumentary coverings and plantar fascia. (2) **Muscles**—(*a*) Tibialis anticus and extensor brevis digitorum: (*b*) the extensor communis digitorum and peroneus tertius; (*c*) the extensor proprius hallucis; (*d*) peroneus longus and brevis; (*e*) the tibialis posticus; (*f*) the first layer of muscles of the sole of the foot (flexor brevis digitorum, abductor hallucis, and abductor minimi digiti); (*g*) the second layer of muscles (the tendons of the flexor longus digitorum and flexor longus hallucis, accessorius and lumbricales); (*h*) the most of the muscles of the third

layer (flexor brevis hallucis, adductor hallucis, flexor brevis minimi digiti, and transversus pedis). (3) **Vessels**—(*a*) the internal plantar artery; (*b*) the external plantar artery, with the plantar arch and its digital branches; (*c*) the dorsal artery of the foot, with its tarsal and metatarsal branches. (4) **Nerves**—(*a*) Anterior tibial or its branches; (*b*) the plantar nerves; (*c*) digital branches of the musculo-cutaneous or peroneal nerve; (*d*) the digital branch of the external saphenous nerve. (5) The **ligaments** of the various joints opened into; and, further, we may specially mention the long and the short plantar ligaments and the inferior calcaneo-scaphoid. The structures divided in HEY'S operation are almost the same as the above, with the following exceptions:—the tibialis anticus and posticus are not divided, and part of the internal cuneiform bone is removed. In LISFRANC'S operation this bone is not divided.

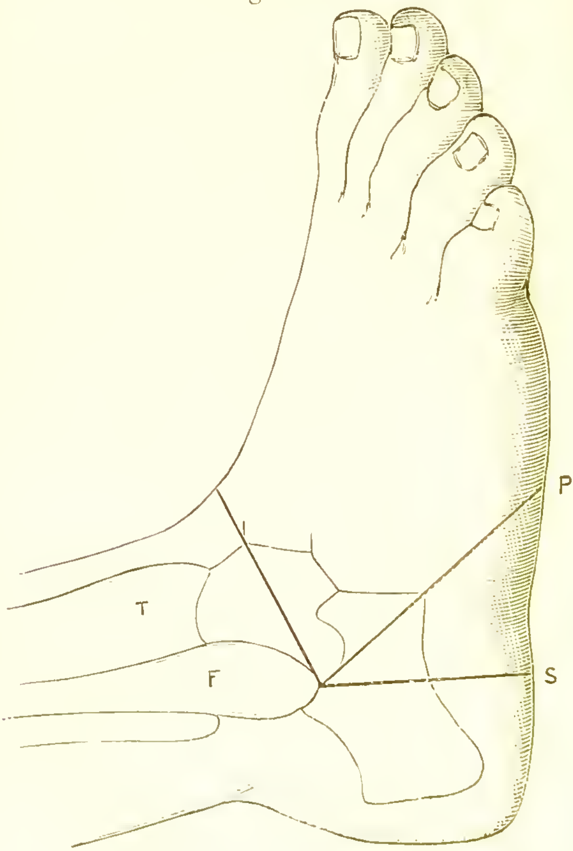
THE ANKLE JOINT.

1. **Syme's Method.**—As in all amputations of the foot, the tibial arteries are to be secured by the thumb and fingers of an assistant—the thumb being pressed over the anterior tibial at a point midway between the two malleoli, the fingers over the posterior tibial about half an inch behind the internal malleolus—or else by an elastic tourniquet applied two inches above the ankle joint, or at the lower third of the thigh.

An **assistant** grasps the toes and holds the foot at right angles to the leg with the heel projecting over the edge of the table, or over a block, while the operator is making the heel flap. The only **instruments** required are an ordinary saw, probably a lion forceps, artery

forceps, ligatures and scissors, and a knife—the blade of the knife should not exceed four inches in length, and it should have a strong back as well as a large and

Fig. 18.



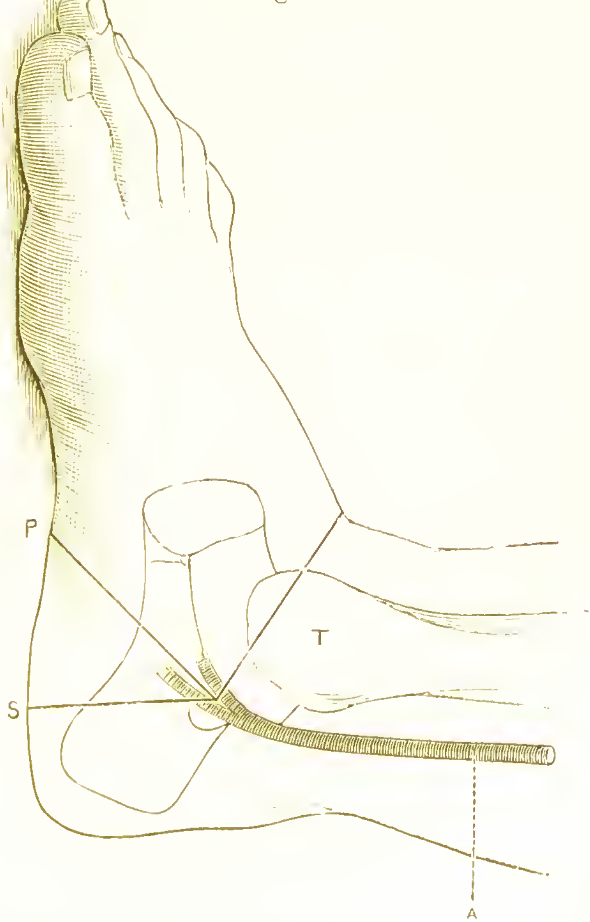
OUTER SIDE OF RIGHT ANKLE.

T. Tibia. F. Fibula. S. Line of Syme's amputation.
P. Line of Pirogoff's amputation.
Note the relation of the incisions to the external malleolus.

strong handle. The guides for this operation are—the external malleolus on the outer side, a point rather

nearer its posterior than anterior edge, and a point *exactly opposite* this on the inner side, *i.e.*, a point about

Fig. 19.



INNER SIDE OF RIGHT ANKLE.

T. Tibia. S. Line of Syme's amputation. P. Line of Pirogoff's amputation. A. Posterior tibial artery.

Note the relation of the angle, formed by the two parts of Syme's incision, to the internal malleolus—below and behind; also that the posterior tibial artery is divided in this angle, just after its division into the two plantar arteries.

half an inch behind and below the internal malleolus, as the external malleolus is longer than the internal and also posterior to it (Figs. 18, 19, S.). The foot being held as directed, the Surgeon takes his place facing the foot, and grasps the heel with the palm of his left hand, and places his thumb and forefinger on the two points already named, and then carries an incision from the one to the other across the sole, inclining slightly backwards, cutting down to the plantar fascia and bone at once—the point of bone cut down upon should be the large internal tubercle of the os calcis; the heel flap should contain no muscular tissue. Should the flap extend in front of the tubercles great difficulty will be experienced in dissecting it back over the os calcis. In raising the heel flap the operator places the fingers of his left hand behind the os calcis (or rather below as the foot is now held) and inserts the point of his thumb between the edges of the plantar incision. In the dissection he must keep the edge of the knife close to and parallel with the bone, guiding it with his thumb nail till the os calcis is fairly turned and the insertion of the tendo Achillis comes into view. The nail not only guides the knife, but pushes the flap downwards, and also prevents the edge 'scoring the flap.' The operator then grasps the front part of the foot with his left hand, fully extends the ankle joint, and unites the two ends of his first incision by another across the front of the ankle 'forming an angle of 45° to the sole of the foot and long axis of the leg' (Syme), in other words, he cuts as straight as possible across the front of the ankle, dividing all the tendons, vessels, and nerves. Mr Heath directs it to be made at right angles to the first. (Mr Syme, we believe, made this

incision immediately after he made the plantar one, and therefore before the heel flap was dissected back, and this is the method still followed in the Edinburgh School). The anterior flap is then to be seized by the assistant and drawn slightly upwards, while the operator frees it a little if necessary. The ankle joint is then opened from the front, and the lateral ligaments on each side divided by the point of the knife applied between the malleoli and the astragalus. In disarticulating the operator must be careful not to injure the posterior tibial artery as it lies in a groove on the posterior surface of the astragalus. The foot can now be dislocated forwards, and is pressed downwards, while the tissues behind the os calcis are divided with the edge of the knife kept close to the os calcis, and the removal of the foot completed by the division of the tendo Achillis. The knife is then to be carried round the tibia and fibula to prepare them for the saw, while the assistant retracts the flaps; the external malleolus is next to be grasped with the lion forceps, and then both malleoli are sawn off including a thin slice of the intervening part of the tibia—just enough to include all the cartilage covered surface. The saw must be kept parallel with the lower end of the tibia, that is to say, at right angles to the axis of the limb, the blade neither being allowed to cut obliquely in the antero-posterior direction, nor yet from side to side. Both in clearing the bone and in sawing it the operator must again be careful of the posterior tibial artery, and also the vessels that lie behind the two malleoli—the continuation of the peroneal behind the external malleolus, and a branch of the posterior tibial behind the internal. In dissecting the heel flap by keeping the knife close to the bone we

avoid making button holes, and also 'scoring' the flap, which is especially objectionable, as it severs large numbers of fine vessels on which the nutrition of the heel flap chiefly depends, and which form long anastomosing loops close to the bone, and running chiefly in the antero-posterior direction (as looked at in the position of amputation). When the incisions are made according to Mr SYME's directions the posterior tibial artery is not cut till after its division into internal and external plantars (BELL); the point of section is just in the angle where the two incisions meet on the inner side (Fig. 19). Some difficulty may be experienced in stitching the hard edge of the heel flap to the thin skin forming the anterior. Before stitching up the wound it is necessary to secure every vessel that can be seen, as well as the dorsalis pedis (or the termination of the anterior tibial) and the two plantar vessels, to avoid as far as possible any general oozing. As regards drainage we can either make a *longitudinal* slit in the lowest part (as the patient lies in bed) of the heel flap, or perhaps the better and more usually adopted plan is to pass a drainage tube through the stump transversely, bringing its ends out at the angles where the two incisions meet. This latter plan is amply sufficient, especially if the patient be taught to lie for some time on the affected side with the amputated limb flexed at the knee and in front of the sound leg, so that the discharges may escape at the fibular angle. Should all go well the tube may be safely removed in a few days. If the plantar incision is made from malleolus to malleolus the flap is not symmetrical, and the incision in the sole extends too far forwards, which makes it a very difficult and serious task to turn it back over the prominence of the

heel: and very likely before this is accomplished, irreparable injury has been inflicted on the heel flap, which results in its sloughing.

2. Mackenzie's Method—By a Large Internal Flap (*also called Roux's Amputation*).—The foot to be amputated is laid on its outer side and firmly held by an assistant, with the foot and ankle projecting over the edge of the table or over a block of convenient height. The Surgeon then places his thumb and fore-finger on the tendo Achillis at the one side, and the tendon of the tibialis anticus on the other, at the level of the ankle joint. He then inserts the point of the knife over the centre of the tendo Achillis, and cuts obliquely across that tendon towards the outer and plantar aspect of the heel, along which it is continued for a little way in a semi-lunar direction, and is then curved upwards in front of the internal malleolus, and terminates on the inner side of the tendon of the tibialis anticus, about an inch in front of the inner malleolus Another incision is then made, without removing the knife from the wound, by carrying it across the outer aspect of the ankle, forming a semi-lunar flap, uniting the two ends of the first incision; the convexity of the flap should be about half-an-inch below the external malleolus. The flaps are then to be dissected up, taking care of the posterior tibial artery which is found in the centre of the large internal flap. Disarticulation is then performed, the tibia and fibula cleared and sawn as in Syme's amputation, and with the same precautions. The advantages claimed for this method are—(1) It can be performed in cases where the tissues on the outer side of the foot have been destroyed by disease or accident. (2) When the patient lies on his

side the large internal flap is kept in good position by its own weight. (3) There is a free exit for discharges, &c., from the posterior and outer side, so that there is less risk of pain and tension and putrefaction of the accumulated discharges. It is a curious fact that the stump in this amputation in a very short time comes to resemble so closely the stump in Syme's amputation that it is almost impossible to tell the one from the other.

3. **Pirogoff's Method.**—The peculiar feature of this amputation is the preservation of the posterior part of the os calcis in the heel flap, which is adjusted to the cut surface of the tibia and fibula. The foot is held at right angles to the leg, and the incision begins and ends at the same points as in Mr SYME'S amputation (Figs. 18. 19, F.), but is not made directly across the foot as in that method but should be carried obliquely forwards, so that the centre of the incision in the sole is an inch-and-a-half in front of a line drawn transversely across the sole from the tip of one malleolus to the other. The incision must go down to the bone obliquely, and therefore the blade of the knife must not be held at right angles to the sole, but obliquely. The edge of the flap may then be freed from the bone for about a quarter of an inch; the foot is next to be extended, and a *straight* cut is made across the front of the ankle joint uniting the two ends of the first incision. Disarticulation is next performed as in Syme's amputation, by opening the thin anterior ligament of the ankle joint and then dividing the strong lateral ligaments with the point of the knife inserted between the malleoli and the astragalus. The foot is still further extended, and the fatty tissue in front of the tendo Achillis cleared,

exposing the posterior part of the upper surface of the os calcis: and the bone also more fully cleared in the line of the first incision. The operator then draws the foot well downwards, its sole resting on the table or overhanging its edge, while the assistant grasps and steadies the heel. A narrow saw with a movable back (but an ordinary saw will do well enough) is then applied midway between the astragalus and the tendo Achillis and a section made through the os calcis obliquely downwards and forwards in the line of the first incision. If the foot is held overhanging the edge of the table, or a block, during this part of the operation the section will seem almost vertical. He next removes a slice from the end of the tibia and fibula, not transversely and at right angles to the axis of the bone as in Syme's amputation, but obliquely, so as to remove more of the posterior than of the anterior surface of the bones—just the reverse of the section through the os calcis. The osseous surfaces are then to be accurately adjusted, and the limb so placed as to relax the muscles forming the tendo Achillis and thus avoid tilting the part of the os calcis in the heel flap. The *oblique* section through the os calcis is to insure that the dense tissues covering its *lower* part are exactly at the end of the stump, and will receive the weight of the body; further it exposes a larger surface of bone to apply against the cut ends of the tibia and fibula, and the retained part of the os calcis does not require to be tilted so much on its own axis in order to adhere closely to the tibia and fibula, and has therefore less tendency to be displaced by the tendo Achillis. Should, however, the tendency to tilting be great the tendo Achillis may be divided, or the bones may be

'wired' together. Originally Pirogoff used a vertical cut through the os calcis, and a transverse one, like Syme's, through the bones of the leg. This, of course, necessitated a greater dissection of the heel flap, which had to be reflected a little beyond the line of the ankle joint.

The **advantages** claimed for this method are—(1) It leaves a longer stump. The advantage of this is contested; some saying that the stump left after Syme's amputation is just the proper length to admit of a suitable spring being placed in the boot; others, among whom are the names of some well-known makers of mechanical appliances, state that the apparatus used after Pirogoff's amputation is the most perfect that has as yet been constructed. (2) It is more easy of performance than a Syme, as it saves the tedious and difficult dissection of the heel flap, but the bones require more accurate adjustment. (3) There is less liability to sloughing of the heel flap, as the vascular supply is less disturbed. (4) It is said to bear pressure better. Its **disadvantages** are—(1) Return of the disease in the fragment of bone left in the heel flap, and therefore this method should never be chosen in the case of disease of the bones of the ankle joint. (2) Greater liability to osteo-phlebitis and pyæmia, owing to the section of the two spongy bones. (3) The process of union and consolidation of the bony surfaces is more tedious.

Subastragaloid amputation (Nélaton).—Removal of the foot below the astragalus through the joint between it and the os calcis. The **guides** for this operation are:—A point three-quarters of an inch below the external malleolus, and opposite the outer tubercle of the os calcis, on the outer side, and the tuberosity of

the scaphoid on the inner side. Commencing on the outer side (right foot) the incision is carried forwards for a little way, and then downwards to the sole of the foot, passing just behind the prominence of the fifth metatarsal bone, across the sole and brought up to the tubercle of the scaphoid on the inner side. The ends of this incision are connected by another curved incision across the dorsum of the foot. The soft parts are next raised on the outer side sufficiently to reach the tendo Achillis, which is to be cautiously divided. The finger is now introduced into the wound, to feel for the articulation between the os calcis and the astragalus, the point of the knife is then pushed in between the bones and the strong interosseous ligament divided, while the foot is wrenched forcibly inwards. The astragalo-scaphoid articulation is next opened, and then the parts on the inner side and the rest of the heel flap are put on the stretch by twisting the foot, separated from the os calcis and the foot removed. In cases where the flaps are somewhat scanty the head of the astragalus may be sawn off. A serious objection to this method is the fact that it leaves a loose bone at the end of the stump over which the patient has no control, and which must of necessity, therefore, cause great insecurity during progression.

Hancock's Amputation.—This consists of amputation below the astragalus, and at the same time leaving the posterior third of the os calcis, which is turned up against the denuded surface of the astragalus. It, therefore, bears the same relation to Nélaton's amputation as that of Pirogoff does to Syme's. The incisions must extend further forwards than in Nélaton's amputation, passing on the one side to a point half an inch

anterior to the projecting end of the fifth metatarsal bone, and to a corresponding point on the other. These incisions are then united by a third semi-lunar incision with its convexity towards the toes. The flap thus marked out is to be reflected nearly as far back as the tuberosities on the under surface of the os calcis, and then a fourth incision is carried across the dorsum of the foot, just behind the head of the astragalus. Next, the posterior third of the os calcis is divided by the saw applied to its under surface, the other tarsal bones are separated from the astragalus, and the foot detached. The head of the astragalus is sawn off, its inferior articular surfaces denuded by the bone forceps, the vessels tied, the posterior third of the os calcis turned up against the denuded surface, the flaps fixed, and the operation completed. The wound is drained from the lower angles, which are left open.

The alleged **advantages** of this operation are—(1) It leaves a longer stump; (2) the greater amount of leverage afforded by the astragalus for the artificial foot. In cases of disease of the tarsal bones it is a doubtful operation, unless one could be quite certain that the retained bones were perfectly healthy; and, as already stated, the astragalus and the os calcis are, of all the bones, the most likely to be diseased.

The following is a general list of the more important **structures divided** in the previous amputations in the vicinity of the ankle joint—(1) The integumentary coverings and plantar fascia. (2) **Muscles.**—(*a*) Tibialis anticus; (*b*) the extensor communis and brevis digitorum and peroneus tertius; (*c*) the extensor proprius hallucis; (*d*) the peroneus longus and brevis; (*e*) the tendo Achillis and plantaris; (*f*) the tibialis posticus; (*g*) the

first layer of muscles of the foot (abductor hallucis, flexor brevis digitorum and the abductor minimi digiti); (*b*) part of the second layer (the tendons of the flexor longus digitorum and flexor longus hallucis, and accessorius muscle). 3. **Vessels.**—(*a*) the dorsal artery of the foot or the anterior tibial; (*b*) the internal and external plantar vessels, or else the posterior tibial close to the point where it divides into these vessels; (*c*) the long and the short saphenous veins. (4) **Nerves.**—(*a*) The posterior tibial or plantar nerves; (*b*) the anterior tibial; (*c*) the musculo-cutaneous or peroneal; (*d*) the long and the short saphenous nerves. (5) The ligaments of the ankle joint and the various other joints disarticulated. (6) The ends of the tibia and fibula, and, in Pirogoff's amputation, the os calcis, and, in Hancock's amputation, the astragalus as well as the os calcis.

CHAPTER XVI.

AMPUTATIONS OF THE LOWER EXTREMITY

(Continued).

Amputation just above the Ankle.—In all cases where amputation at the ankle joint cannot be performed, amputation immediately above the ankle should if possible be chosen in preference to that at the 'seat of election,' for two reasons—(1) The longer stump gives greater command over the artificial limb, and instead of, as formerly, using the old 'box-leg' with the stump projecting behind, the knee being flexed and placed between the prongs, the stump is now encased in the socket of a short wooden pin in the extended position. (2) Amputation in this situation is less fatal than amputation higher up. The main artery is secured above the knee as in the previous operations on the foot, or by the thumbs of an assistant against the ilio-pectineal eminence. The limb is placed so that the part to be removed projects over the end of the table, and is held horizontally above the level of the table with the knee joint slightly flexed, by an **assistant** seated on a low stool, the **Surgeon** standing on the right hand side of the leg to be amputated. The other leg is secured to the leg of the operating table.

1. **Teal's Method.**—Long anterior and short posterior rectangular flap. (For a description of the principles of

this method, see p. 166.) The chief objection to this method is that the bones are not divided at the lowest possible point, and therefore the stump is not so useful, and there is, also, a greater risk to life. The large square anterior flap may be taken partly from the dorsum of the foot, so as to bring the point of section of the bones as low down as possible, and it must include everything in front of the bones and the inter-osseous membrane. The anterior tibial artery lies in the middle of this flap, but is very close to the inter-osseous membrane, and should the flap be raised in the ordinary way by the knife, the artery is very apt to be punctured during the dissection; to avoid this undesirable accident—as the nutrition of the flap depends on this vessel—we must follow Mr Teal's plan, who has shown that, on account of the comparatively large amount of loose cellular tissue lying between the anterior structures and the membrane, there is no difficulty in separating the flap from its anterior surface by the finger or thumb nail, or the handle of a scalpel. To render this more easy the lateral incisions, marking the limits of the anterior flap, should go through all the soft tissues down to the bone, especially on the fibular side, on account of the intimate attachment of the muscles to that bone. To insure that the anterior flap shall be of the same breadth throughout it is advisable, before beginning the operation, to measure with a tape and mark the whole extent of the anterior flap in ink, rather than trust to the eye alone, as the cone-shaped form of the limb is apt to mislead the eye. The posterior flap is then made with the same precautions to avoid injury of the arteries and nerve behind. The tibia and fibula are then to be cleared to the level of the base of the flaps, or a little

higher if necessary, and the interosseous membrane divided, and the tissues between the bones cleared, by a figure-of-eight-like sweep. To avoid cracking and splintering of the fibula, both bones are to be divided together, but the fibula must be finished before the tibia. Should the angle in front of the tibia be very acute it should be removed, either by the bone pliers or a small saw. The **vessels requiring ligature** are—(1) The anterior tibial at the middle of the apex of the anterior flap, (2) the posterior tibial, and (3) the peroneal artery, both in the posterior flap.

2. **Long Anterior Flap**, slightly rounded at the corners, and made by dissection. Mr BELL recommends this method, and it was also used by Mr SYME. It is formed on the same principle as, and with all the precautions of, Mr TEAL's anterior flap, and must be long enough to fall down over the face of the bones at the point of section and the stump of tissue behind them. The posterior tissues are divided by a transverse incision at the base of the anterior flap.

3. **Lister's Method** (see p. 168).—Take the *diameter* of the limb at the point where the bones are to be divided, and then make a straight longitudinal incision of that length on the inner aspect of the leg, and another similar incision on the outer aspect directly over the fibula, but extending one inch higher up than the inner one. The lower ends of these incisions are then united by a nearly transverse incision with the angles well rounded, where it joins the lateral ones. The knife is next carried behind the bones, and cutting somewhat obliquely from without inwards, fashions a short posterior flap, about one-half or one-third the length of the anterior, convex downwards, extending

from the upper end of the *internal* lateral incision to a point exactly opposite on the outer side, and will be therefore about one inch below the upper end of the external incision. The anterior flap is raised as in Teal's method, and the bones cleared and sawn at the upper end of the *outer* incision. The fibula and anterior edge of the tibia must be treated in the way already indicated. The flaps are then to be stitched up closely except at the upper end of the external incision, which is left open for drainage, the limb being placed on its outer aspect. The reason why the lateral incision is carried further up on the outer side is on account of the difficulty of retracting the soft parts from the fibula, as the bone is sawn an inch higher up than the proper base of the flaps. They can be retracted without any difficulty from the tibia, and therefore the incision is not carried further up than the typical operation demands.

Other methods are sometimes employed, as—

4. **A Short Anterior Semilunar Flap** made by dissection, and a Long Posterior by transfixion, the bones being divided a little above the base of the flaps.

5. **Modified Circular.**—But of all others the best method is by some form of long anterior flap and short posterior, as in the operations already described; as this affords the best covering since the bones are placed nearer the anterior aspect of the limb, and the cicatrix is out of the way of pressure, so that the patient can bear a part of the weight of the body on the end of the stump, the rest being supported by the prominence of the calf muscles, and the heads of the tibia and fibula. For the **structures divided** see 'Amputation through the Calf,' but adding to the list there given—(1)

Peroneus tertius muscle, and (2) anterior peroneal artery.

UPPER TWO-THIRDS OF THE LEG.

The limb is to be drained of blood and hæmorrhage provided against as in the previous amputations—either by the elastic tourniquet applied above the knee, or else by the thumbs of an assistant pressing on the femoral artery below Poupart's ligament.

1. **Long Anterior Skin Flap and Short Posterior Flap of Skin and Muscle.**—The limb is held in a way similar to that of the previous amputations, and rotated well inwards, so as to throw the fibula well forwards. The operator takes his stand on the right side of the limb to be removed, so that he can grasp the limb above the point of amputation, and, in the case of the *right* leg, places his thumb on the fibula, and his fore-finger at a corresponding point on the opposite side, which will therefore be considerably behind the inner edge of the tibia. On the left side the position of the thumb and finger will be reversed, as the operator then takes his stand inside the limb. He then marks out a broad skin flap, equal in length to two-thirds of the diameter of the limb, the heel of the knife commencing well behind the tibia, its blade sweeping across the front, and its point ending a little behind the thumb; next, without removing the knife from the incision, he transfixes the limb behind the bones, taking care not to pass the knife between them, and making it enter and emerge through the angles of his former incision, so that the blade will pass close behind the fibula, but at some little distance from the tibia. A short posterior flap, about half the length of the anterior, is

then cut from within outwards; while the posterior flap is being cut, the assistant holding the foot must keep the muscles tense by dorsiflexing the foot forcibly, while the operator or another assistant pulls up the skin as far as possible. This insures the skin being cut longer than the other tissues, and avoids redundancy of muscle. The operator must next raise the anterior flap, which at first should consist entirely of integumentary structures, but, as its base is approached, some muscular tissue may be taken up, as well to insure its nutrition; both flaps are then to be well retracted by the assistant standing opposite the Surgeon, while the knife is swept circularly round the limb at the base of the flaps. The interosseous structures are then to be divided by the usual figure-of-eight like sweep of the knife, taking care not to allow its edge to be directed upwards in the least, lest the anterior tibial artery especially, or any of the other vessels, be split, and retract beyond the reach of easy ligature. The bones are then to be sawn, and the sharp angle removed from the anterior edge of the tibia. In order to do this, it is usual to commence sawing the bone obliquely from a point half an inch above the place where the bones are to be sawn transversely, and when the oblique section has crossed the line of the transverse one, then withdraw the saw and apply it transversely half an inch lower down than the commencement of the oblique cut. When the saw is about half way through the tibia, then alter the direction of the blade, so that it will take up the fibula, which is to be completely divided before the tibia to avoid cracking and splintering of the weaker bone; of course, instead of doing it in this way, the sharp anterior edge may be rounded off with the bone forceps or a small

saw, after the bone itself is divided. It is advised, to lessen the risk of necrosis, to raise the periosteum before the saw or forceps is applied, so that it may not be stripped off to a higher level than that at which the saw is actually applied. The **vessels divided** are—(1) Anterior tibial; (2) posterior tibial; (3) peroneal artery; (4) long and short saphena veins, all of which may require ligature. By this amputation the vessels are cut transversely, and the cicatrix is placed behind.

2. **Lister's Amputation.**—Take the diameter of the limb, by spanning, at the point of the intended division of the bone, and then make a straight longitudinal incision equal in length to two-thirds of this diameter, along the inner aspect of the leg, commencing one inch below the point at which the bone is to be divided. A similar incision is made on the outer aspect, directly over the fibula, but is to be prolonged an inch higher up than the internal incision (*i.e.*, up to the point of section of the bone), for reasons already stated. The two incisions are then united by a transverse cut, with well-rounded angles, at the points where it meets the lateral incisions. A posterior flap is then made from the upper end of the internal incision to a point exactly opposite that in the external incision—that is, one inch below its upper extremity. This flap should be half the length of the anterior, and is made by carrying the knife round the back of the limb with the blade at an angle of forty-five degrees to the horizon, through the integumentary structures only, and dissecting it up to the level of the upper end of the internal straight incision. By this means we get rid of the heavy mass of muscles of the calf. The anterior flap is dissected up to a similar point, both flaps retracted, and the bones

cleared as high as the line of the external incision, and the operation finished as described in the previous amputation.

3. **Modified Circular.**—The leg is held as in the previous amputations, supported horizontally, and well rotated inwards, so as to throw the fibula well forwards; the assistant must also extend the toes forcibly as the operator's knife divides the muscles in front, and dorsiflex forcibly as he divides the posterior group of muscles. In this way muscles are rendered tense and more easily divided. Another assistant, standing opposite the Surgeon, pulls up the skin well, both before and after the first incisions. The Surgeon stands so that his left hand grasps the limb to be removed above the level of the amputation, *i.e.*, on the *right* side; and then cuts two equal semi-lunar flaps of skin from the outside by dissection. In order to cover both bones equally, and avoid their projecting at either of the angles of the incisions, the flaps may be placed rather antero-external and postero-internal. In raising the posterior, the limb should be elevated to enable the Surgeon to see better what he is doing. Both flaps are then retracted and the skin turned back like the cuff of a coat for a little way, and the muscles divided at that level by a circular sweep of the knife, and the bones cleared for an inch or an inch and a half higher up, and there divided with all the usual precautions. As the posterior muscles retract further than the anterior, (being divided at a greater distance from their origin,) they should be divided at a lower level.

Instead of using the pure 'modified circular,' the anterior skin flap may be made equal to two-thirds of the diameter of the limb, and the posterior half that

length. The flaps are then retracted and the operation finished as above directed. The 'modified circular' gives a good stump out of the smallest amount of material, and provides an exceedingly useful limb, the patient either being provided with a properly fitting socket, in which to put the limb, retaining the use of the knee joint, or else resting his whole weight upon the bent knee, as in the old artificial 'box leg.'

4. **The Old Flap Operation.**—This is recommended by many Surgeons, especially in cases of chronic disease, where the muscles of the calf are much wasted. It gives a well-covered stump, with the cicatrix in front, on which the patient can bear a considerable part of his weight. In this operation the **Surgeon** stands so that he can grasp the limb below the seat of the amputation—on the inner side, on the right leg, and the outer, on the left. An **assistant** takes his place opposite the operator, and must be prepared to pull up the integument, steady and support the upper part of the limb, and retract the flaps when they are formed. The operator then places his forefinger and thumb on the fibula on the one side, and the inner edge of the tibia on the other, and then places the heel of his knife (on the right limb) over the outer margin of the fibula, carries it downwards for about an inch and a half, then sweeps the blade across the front of the limb in a semi-lunar manner, and then upwards till it reaches a point a little *behind* the inner edge of the tibia, and opposite the commencement of the incision on the outer side. Then, without removing the point of the knife from the incision, he transfixes the limb, the knife entering and leaving at the angles of the former incision, and forms a gently rounded flap from the calf, by cutting

first downwards for some distance and then gradually outwards. The anterior flap is then dissected upwards, the assistant holding it while the operator frees it by a few touches of the knife—if preferred, the anterior flap may be dissected up before the posterior flap is made. Both flaps are next retracted, the bones cleared and sawn a little higher up than the point of transfixion, with all the previous precautions. The great objection to this amputation is the great mass of muscle left in the posterior flap, which is therefore apt to bag and drop, owing to its great weight, and leads to tension and sloughing: for the same reason it must be kept in position by strapping, &c., and this is a source of great discomfort and pain to the patient, as well as being likely to interfere with primary union of the wound. To get rid of this difficulty to a certain extent, Mr Spence advised that the skin of the posterior flap should be retracted and the redundant muscle removed by a single sweep of the knife, thus leaving little more than a skin flap. No doubt this is a great improvement: but even this does not give the advantages of the large anterior flap, viz.:—(1) Cicatrix placed behind; (2) a dependent opening for drainage during healing; (3) the long anterior flap is kept in position by its own weight: (4) the tendency to protrusion of the bone is less as ulceration of the flap is rare, as the heavy muscular mass in the posterior flap is avoided.

5. **Lee's Amputation** THROUGH THE CALF.—This amputation resembles, in a general way, Teal's amputation, only the long rectangular flap is made from the tissues behind instead of from the front. The incisions are made at first through the skin and cellular tissue only, and when this has retracted, by virtue of its own

elasticity, the muscles are divided; the superficial muscles only are included in the posterior flap, the deep muscles with the large vessels and nerves are cut at the base of the flaps. It was hoped by this method to combine all the advantages of Teal's amputation together with the ease of performance of the old flap method. But, as already pointed out, the question of ease and time is not of so much importance now-a-days, as it is to secure a good, useful stump.

6. **The Circular Method** *('triple incision')* may be used in cases where there is not sufficient skin to form a long anterior flap. The steps of the operation resemble very closely those of the modified circular, the only difference being that the skin is divided circularly instead of in the form of two short equal semi-lunar flaps.

The foregoing six methods may all be employed either in the middle third of the leg, or at the old 'seat of election.' The 'seat of election' is about a hand's breadth below the knee joint, and leaves just sufficient tibia to retain its tubercle with the insertion of the ligamentum patellæ. In practice, however, it will be found more convenient to go a little lower down if possible. If the bones are divided at the 'seat of election,' some difficulty will probably be experienced in securing the anterior tibial artery, which at that point is just passing through between the bones, and is therefore apt to retract after division, beyond the reach of easy ligature (see p. 160); but, by going a little further down, the artery is fairly through and lying on the anterior surface of the interosseous membrane and may be more readily secured. The head of the fibula should always be left, as usually its synovial membrane is but a part

of the general synovial membrane of the knee joint. In regard to arteries divided in amputations a little below the keee, Mr HOLDEN has pointed out that in amputations *one* inch below the head of the fibula *one* artery is divided—the popliteal; at *two* inches below the head, *two* arteries—the anterior and posterior tibials; at *three* inches below the head, *three* arteries—the anterior and posterior tibials and peroneal.

The chief **structures divided** in the foregoing **amputations through the calf** (Fig. 11) are—(1) The integumentary coverings. (2) **Muscles**—(*a*) Tibialis anticus, (*b*) extensor communis digitorum, (*c*) extensor proprius hallucis, (*d*) the peroneus longus, (*e*) the peroneus brevis, (*f*) the gastrocnemius, (*g*) soleus, (*h*) plantaris, (*i*) the flexor longus digitorum, (*j*) the flexor longus hallucis, (*k*) tibialis posticus. (3) **Vessels**—(*a*) The long saphenous vein, (*b*) the short saphenous vein, (*c*) the anterior tibial vessels, lying on the interosseous membrane, (*d*) the posterior tibial vessels, lying on the tibialis posticus, (*e*) the peroneal vessels (about the middle of the leg these will be found in the substance of the flexor longus hallucis, higher up they will be found lying on the tibialis posticus). (4) **Nerves**—(*a*) The short saphenous, or the branches going to form it, (*b*) the anterior tibial nerve, (*c*) the posterior tibial nerve, (*d*) the peroneal nerve. (5) Tibia and fibula. (6) The interosseous membrane.

THE KNEE JOINT.

Amputation at the Knee Joint Proper (leaving the condyles).—This is an amputation but rarely performed, although of recent years it seems to be reviving. The difficulty is to get sufficient covering, on account of the

large size of the lower end of the femur. In the case (1) of *disease* of the joint there can be no doubt that the amputations of Carden or Gritti are immensely superior to amputation at the knee joint, for the proper performance of which it is necessary that the articular surfaces of the condyles and patella should be healthy. Many Surgeons, however, operate thus, even in disease of the joint, and after disarticulation is completed, use a fine bladed Butcher's saw and cut *round* the end of the bone, thus removing the diseased surface without shortening the stump or lessening its breadth. An objection to this proceeding is that the cancelli may be opened up and predispose to osteo-phlebitis and pyæmia. For this reason when the cartilages are healthy they should be left undisturbed on both femur and patella: and the cartilage, if removed from the one should also be removed from the other. In the case (2) of *injury*, when the integuments are uninjured for *five* inches below the patella (the length of the anterior flap in amputation by the long anterior skin flap — the best method—it is better to amputate by the *modified circular* at the old seat of election. It may, however, be practiced in the case of malignant disease of the head of the tibia, provided the femur and knee joint are healthy, and in gun shot wound of the same bone.

1. **By Long Anterior and Short Posterior Flap.**— This is the method usually preferred. An **assistant** holds the leg in an extended position while the anterior flap is fashioned. The **guides** for the anterior flap are the lower and back part of each condyle, and a point an inch or more below the tubercle of the tibia. The flap should be broad and somewhat square-shaped, with its lower angles well rounded, and must be at

least five inches long. It will be convenient for the Surgeon to stand on the right side of the limb to be amputated, so that he may himself raise up the large anterior flap with his left hand; he should be provided with a short broad-bladed amputating knife. The anterior flap is then marked out in the manner indicated, the ligamentum patellæ divided, and the integument with the patella and capsule are dissected up in front of the joint; in this way the articulation is opened. One assistant now flexes the knee joint, and another supports the thigh, while the operator divides the lateral and crucial ligaments, and passes the knife straight backwards between the bones turns it down behind the tibia and cuts a posterior flap fully one-half the length of the anterior. This flap may be made by cutting from behind forwards, instead of from before backwards. In both cases the knife must be made to enter or leave the tissues abruptly so as to keep the end of the flap squarish and divide the poplitical artery transversely. The flap must not be made any *shorter* than the length given, as it shows a considerable tendency to retract. The treatment of the patella is a disputed point. On the whole, I think, Surgeons are inclined to leave it, as it fills up the hollow between the condyles to which it may or may not become ankylosed; in any case it protects the end of the stump, and the position of its bursa makes it useful in supporting the patient's weight. The only objection to this is that it is occasionally drawn up in front of the thigh by the quadriceps extensor cruris; this may be prevented either by cutting the tendinous insertion of that muscle into the patella, or by 'wiring' the patella to the condyles by silver wire or strong cat-

gut. If the patella is to be removed it may either be done during the formation of the anterior flap, by dissecting it off and cutting above it when opening the joint, or dissected out after the flap is raised; but by removing it the bursa is lost and the flap is so thinned that it is apt to perish by sloughing. A most important part of the after treatment is the proper drainage of the wound as in all cases where large synovial pouches are opened. This is best accomplished by the introduction of two long drainage tubes, inserted into the extreme upper corners of the pouches and their ends brought out at the two angles of the wound. They must not be interfered with till the third day, and must never on any account be completely removed during the dressing of the wound, as it would probably be impossible to replace them; they must simply be withdrawn half an inch or so at each dressing and the projecting piece cut off, as the wound heals.

2. **Short Anterior and Long Posterior Flap.**—The leg is held as in the previous operation, and the Surgeon may either stand on the right or left side of the limb. A slightly curved incision is made from the lower and back part of one condyle, passing just below the patella, and ending at the lower and back part of the other condyle. This flap is then dissected up, the knee flexed, and the joint opened above the patella, by a semi-circular sweep of the knife. The lateral and crucial ligaments are next divided, the bones fully separated by dividing the posterior ligament, and the knife passed behind the tibia with its edge directed downwards, and a large flap about four or five inches long cut from the upper part of the calf of the leg. In making this posterior flap the assistant must flex and displace the tibia a little for-

wards till the knife is fairly behind it; then the skin is to be drawn well upwards, and the leg extended as the knife cuts the flap. As usual, the knife must be carried down close to the bone for some distance, and then brought abruptly out so as to make the end of the flap rather square than round. The great OBJECTION to this amputation is the tendency of the posterior flap to retract.

3. **By Lateral Flaps** (SMITH, New York).—Two convex lateral incisions are made from a point on the anterior edge of the tibia, one inch below the tubercle, and carried downwards and backwards, round the two sides respectively, over the most prominent part of the side of the leg, and are then directed upwards reaching the median line posteriorly at a point opposite their commencement. From this a single straight incision is carried directly upwards to the centre of the popliteal space. The flaps are then raised, the ligamentum patellæ divided, disarticulation performed, and the limb removed. The patella is left, and the internal flap is rather larger than the external. It will be observed that this somewhat resembles the 'oval' method of amputation, with the muscles divided obliquely towards the bones.

In amputation at the knee joint the **structures divided** are—(1) The integumentary coverings. (2) **Muscles**—(*a*) The lower part of the quadriceps extensor cruris, (*b*) the adductor magnus, (*c*) the gracilis, (*d*) the hamstrings, (*e*) the sartorius, (*f*) the gastrocnemius, (*g*) the plantaris, (*h*) the soleus, (*i*) the popliteus. (3) **Vessels**—(*a*) The popliteal artery (in the posterior flap) with its lower articular branches, (*b*) branches of the anastomotica magna of the femoral, (*c*) long and

short saphena veins, (*d*) the popliteal vein. (4) **Nerves**—(*a*) The internal popliteal with its *ramus communicans tibialis*, (*b*) the external popliteal with its *ramus communicans fibularis*, (*c*) cutaneous nerves of this neighbourhood, (*d*) branches of the obturator nerve supplying the knee joint. (5) The ligaments of the knee joint.

AMPUTATION THROUGH THE CONDYLES.

This is often spoken of as amputation *at* the knee joint, and is more frequently performed than that operation.

1. **Carden's Amputation** *(slightly modified)*.—This is analogous to Syme's amputation at the ankle joint. The **guides** are the two condyloid eminences of the femur, which correspond to the broadest part of the articular end, and the tubercle of the tibia. Carden himself simply made an anterior flap, removing the patella, and cut through everything on the posterior aspect straight out at the base of the anterior flap, not making a posterior flap at all. Other operators, however, have found that without a posterior flap the covering is frequently insufficient, especially in cases where the leg has been fixed in the flexed position by disease. An **assistant** holds the limb with the knee joint fully extended. The **Surgeon** stands on the right side of the limb, and places his finger and thumb on the two condyloid eminences of the femur, and, therefore, nearer the posterior part of their lateral aspect than the anterior. He then marks out a long anterior flap, reaching as low as the tubercle of the tibia—the knife being entered behind, and close to his finger, and brought round to a point, close to and behind his thumb, or *vice versâ* according to the limb. The flap

should be broad, and its edges at first straight, and its lower angles well rounded. It is then dissected up, with or without the patella; if without, when the dissection has proceeded as far as the centre of that bone the assistant forcibly flexes the knee to a right angle; this pulls the patella down, and then the operator cuts into the joint by a semi-circular sweep of the knife above the upper edge of the patella and immediately above the condyles. When the soft parts are much thickened and matted by disease the patella may be turned up with the flap and dissected out afterwards. The lateral, crucial, and posterior ligaments are next divided, the knife passed behind the femur, and a posterior flap cut from within outwards nearly equal in length to the anterior; it is better to make it pretty long, because it contains the hamstring tendons, and will retract considerably. Mr Bell makes a skin flap about an inch and a half long, allows it to retract, and then divides the muscles by a circular cut down to the bone at the level of the retracted skin. Both flaps are then retracted, the bone cleared to the highest point of the articular surface, and then sawn through at the broadest part of the condyles; the saw must be applied parallel with the articular surface of the femur, and not at right angles to the long axis of the bone, and to avoid injurious pressure on the anterior flap, the sharp anterior edge of the condyles may be *rounded* off by a narrow bladed and fine toothed Butcher's saw. It is not necessary to adhere strictly to the order of the operation as above described; the anterior flap may be cut and raised, the knee joint examined if the Surgeon is undecided between excision and amputation, the bone sawn as in excision, and then, should amputation be

deemed necessary, the short posterior flap of skin is marked out, allowed to retract, and then the muscles and vessels divided last of all. By this plan the patella is raised with the anterior flap and will require to be dissected out before completing the operation.

In performing this amputation, Mr HEATH at once flexes the knee to a right angle, makes the first incision and reflects the anterior flap, then transfixes the limb behind the condyles, and forms the posterior flap.

As compared with amputation through the lower third of the thigh, CARDEN's amputation has the following advantages:—(1) It is less serious because further from the trunk, and there is therefore less shock, &c. (2) The parts divided are not vascular, and therefore there is less risk of hæmorrhage. (3) The tendency to protrusion of the bone is less, because of the ample coverings, and less tendency to necrosis, osteomyelitis, osteo-phlebitis, and pyæmia as the medullary canal is not opened. (4) A longer stump, and therefore greater command over the artificial limb. (5) The end of the stump is well adapted for bearing pressure, being of great breadth, and further because the skin forming it is accustomed to bear pressure, and the cicatrix is situated behind. (6) In cases of doubt as to whether amputation or excision is the proper mode of procedure, the anterior flap can be raised, the joint examined, and the further proceedings decided: for like Spence's amputation at the shoulder, it is very easily transformed from an excision into an amputation should the case demand it.

2. Gritti's Amputation *(slightly modified).*—This to a certain extent resembles very closely CARDEN's amputation. We have the same guides for the anterior

flap, which is dissected up *with the patella*. The operation is finished as in CARDEN, the articular surface of the patella is sawn off, and the denuded surface hangs over the end of the femur. The femur is divided about one-third of an inch higher up than in CARDEN, to insure that the patella will hang flatly over it and not tilt. It has been advised, just as in amputation at the knee joint proper, to divide the tendon of the quadriceps extensor cruris, or 'wire' the bones to keep it from tilting. This amputation, therefore, has the same relation to CARDEN'S as PIROGOFF'S has to SYME'S amputation at the ankle joint. Its great advantage is that the bursa patellæ is retained, upon which the patient can bear a great part of his weight; there is probably also less risk of sloughing of the anterior flap. An alleged disadvantage is that the femur being divided higher up, the medullary canal is more apt to be opened, and the patient therefore runs the risk of osteomyelitis and its consequences; further for the same reason the end of the stump is not quite so broad as in CARDEN. In denuding the patella of its cartilage, an assistant must at first grasp it transversely with a lion forceps and hold it vertically down upon the femur till the saw has made a groove for itself, and then the operator himself holds the flap and patella with his left hand and saws vertically downwards.

Lister's Amputation *(a form of 'modified circular.')*—He suggested this method to lessen the risk of sloughing of the large anterior skin flap in Carden. The integuments behind are also made to take a larger share in forming the covering, and therefore it is not necessary to go so far down the limb in front, and hence might be used in case of injury. The incisions he advises

are the following:—The limb being extended, the Surgeon stands on the right side and cuts almost transversely across the front of the tibia from side to side, at the level of the tubercle of the tibia, and joins the horns of this incision by carrying the knife at an angle of 45 degrees to axis of leg through skin and fat. The leg is then elevated and the posterior flap dissected up, and the ring of integument reflected as in the circular operation, dividing the ham-strings as they are exposed, The knee is next flexed, and the upper border of the patella exposed when he cuts into the joint above it by a semicircular sweep of the knife. The bones are now cleared and sawn as in Carden's amputation. For the structures divided in the three foregoing amputations, see amputation through the knee joint proper. Of course the section through the femur must be added in all, and in Gritti section of the patella as well.

CHAPTER XVII.

AMPUTATIONS OF THE LOWER EXTREMITY

(Continued).

The Thigh.—In all amputations through the thigh the amount of flap length allowed should never be less than twice the diameter of the limb at the point where the bone is sawn, and, if possible, the anterior flap should be longer than the posterior.

LOWER THIRD.

1. **Spence's Method,** by long anterior flap (see p. 167).—An **assistant,** seated in front of the patient on a low stool, holds the limb firmly below the knee, so that the thigh shall be horizontal and projecting from the buttock over the edge of the table; another assistant takes his place opposite the Surgeon. The **Surgeon** stands on the left side of the limb to be amputated, so as to command the bone, whilst he is sawing it. He then measures, with his eye, the breadth of one half the circumference of the thigh, and inserts his knife into the side of the limb furthest from himself, carries the incision downwards to below the lower edge of the patella, sweeps across the front of the knee with a gentle curve, and then straight upwards, and ends at a point exactly opposite to that at which he commenced,

the assistant standing opposite him, retracting the skin and fascia all the while. The leg is still kept in the extended position, and the Surgeon dissects up the flap from off the patella, taking care not to buttonhole it, and, on reaching the upper border of that bone, he cuts deeply and obliquely upwards, so as to take up the muscular tissue as well, towards the base of the flap; the flap should be nearly as broad at its apex as at its base, and is at first composed of skin and fascia only. He next shapes a posterior flap, about two and a half inches below the base of the anterior flap, making a convex incision through the integuments and cuts the other soft tissues obliquely upwards towards the bone. The leg assistant now elevates the limb to a right angle with the table, retracts the soft parts, and the bone is cleared by a couple of sweeps with the knife, *two inches* higher up than the base of the flaps. By elevating the thigh the bone is projected to the utmost, and, when the limb is brought down again after sawing, it will be found to be deeply buried among the soft parts; as soon as the bone is divided all further retraction must be avoided lest the periosteum be stripped off the bone that remains, and lead to necrosis. The younger the patient the more necessary is this precaution, as the deep layer of the periosteum is more cellular, and therefore less adherent in the young than in the old. The femoral artery will be found towards the inner side of the *posterior* flap when the operation is properly performed, and should not, on any account, form part of the anterior flap.

Teal's Amputation.—This is performed according to the rules given elsewhere. Measure the circumference of the limb at the point where the bone is to be

divided, and then mark out the long flap, making its length and breadth each equal to the half the circumference of the limb. Trace out the inner longitudinal line first, making it as near as possible to the femoral vessels, without including them in the anterior flap. If the tissues are healthy, the anterior flap may be taken from the front of the knee joint and patella. The posterior flap is next marked out, and its length is to be one-fourth that of the anterior. The lateral incisions are first made, and must only go through the integumentary structures. The anterior flap will probably at first only consist of skin and fascia, but above the upper border of the patella it must include everything down to the thigh bone. The posterior flap is made by a single sweep of the knife down to the bone through muscles, vessels, and nerves. The bone is then cleared and sawn close to the base of the flaps.

3. **The Circular or Modified Circular** may also be used. In the modified circular two equal antero-posterior semilunar flaps of skin are cut according to the method explained elsewhere; they are then retracted to a distance equal to half the diameter of the limb, and the muscles divided down to the bone by a circular sweep of the knife. On account of the unequal retraction, the posterior muscles must be cut much lower than the anterior. All the tissues are then retracted, the bone cleared and sawn.

4. **Lateral Flaps** (VERMALE).—He introduced this method, because the muscles in this part of the limb are chiefly lateral, the central parts in front and behind being tendinous, and, therefore, if antero-posterior flaps were used they would be thin and tendinous in the middle. Lateral flaps are not so, but have the

disadvantages (1) of leaving the cicatrix over the end of the bone; (2) they are difficult to keep in position; (3) thebone tends to be tilted forwards by the psoas and iliacus, and projects at the anterior angle of the flaps; just as the deltoid tilts the humerus in amputation through the middle of that bone by antero-posterior flaps. It has one advantage, however, namely that it provides a free exit for discharges during the process of healing. The limb is held as described under Spence's amputation, and the Surgeon in all cases stands on the outer side of the limb, and the outer flap is always to be made first, as it contains no vessels of consequence. The Surgeon grasps the soft parts on the outer side with his left hand, and draws them outwards, enters the point of the knife perpendicularly in the middle of the thigh, about three inches above the upper border of the patella, thrusts it downwards, passing closely round the bone, and brings it out in the centre of the ham; the flap is then cut downwards and outwards. The knife is again entered at the upper angle of the incision, carried closely round the inner side of the bone, taking care not to transfix the femoral artery, and brought out through the lower angle of the first incision, and a flap cut equal in length to the external one. The limb is then elevated, the flaps retracted, the bone cleared, and the saw applied about four inches above the condyles. In sawing the femur the *linea aspera* must be regarded as a separate and small bone, and the femur must therefore be divided in the same manner as the tibia and fibula, the saw first entered well on the dorsal aspect of the bone, and then brought nearly vertical, so as to divide the *linea aspera* early. The assistant must at the same time support the leg

evenly, so as neither to lock the saw nor snap and splinter the bone. In certain cases where the tissues are damaged on one side only, it may be found advantageous to use the lateral flap method; in other cases, however, it ought to be avoided.

5. **Lister's Method.**—See under amputation of middle and upper third of thigh for description.

6. **Skin Flaps.**—This is hardly a separate method, but should be adopted in cases of malignant disease. The flaps should, if possible, be antero-posterior, and are to be made by dissection, and the other tissues divided circularly above the diseased part. The posterior flap should be raised first, otherwise the bleeding from the anterior will embarrass the operator.

The method of amputation by **double transfixion** is not usually adopted in the lower third of the thigh. The *muscular* flaps—the necessary result of this method—tend to retract too much and lead to protrusion of the bone; the posterior one especially retracts, as the hamstrings are cut so far from their origin, and leave a gaping wound to heal by granulation. This is specially manifested when the limb is flexed—the position of greatest comfort to the patient.

For the **structures divided** see next set of amputations.

MIDDLE AND UPPER THIRDS.

For the different methods of restraining **hæmorrhage** in amputations through the *upper* part of the thigh, see amputations at the hip joint. In amputating in these situations we must save as much as possible, for it is of more importance to preserve the life of our patient than to secure an artistic stump.

1. **Modified Circular.**—By this method we can secure the longest possible stump out of the structures at our disposal. The **operator** stands on the right side of the limb, and three **assistants** are required—**one** to support the limb below the seat of amputation, a **second** to support the thigh and retract the integument, and a **third** to command the femoral artery. The patient's other leg is secured to the leg of the operating table, by a clove hitch. The two short skin flaps may be taken from the most convenient position; if it is a matter of choice, then make them antero-posterior. Retract the flaps of skin and divide the muscles, taking care that the posterior ones are divided at a lower level than the anterior. Next retract all the tissues and saw the bone higher up. In wasted and almost cylindrical limbs the ordinary circular or '**triple incision**' may be adopted. In the circular method the **operator** stands on the outer side of the limb. **One assistant** supports the limb horizontally, while **another** encircles the limb with both hands above the seat of the amputation, and retracts the integuments, and, in the living body, a **third** must compress the femoral artery against the brim of the pelvis. In all cases of thigh amputations, the **patient** is laid upon his back, with his buttocks close to the edge of the table, the leg to be amputated projecting horizontally from it, and the other secured to the leg of the table.

2. **Double Flaps by Transfixion.**—The anterior flap must be equal in length to two-thirds of the diameter of the limb at the point of section of the bone; the posterior half that length. The **assistants** required are the same as in the previous operation, and the **Surgeon** stands, most conveniently, on the right side of the limb.

The assistant standing opposite the operator, places the palm of his hand on the posterior part of the thigh to be amputated, so as to press up the soft parts and relax those in front. The operator then grasps and raises the anterior structures with his left hand and transfixes the limb one and a half inches below the point where the bone is to be sawn, passes the knife close in front of the bone and femoral artery (below the middle of the thigh), so as to give a broad flap, as nearly as possible equal to half the diameter of the limb. The knife is again re-entered *one inch below* the point of the first transfixion, lest the heel cross-cut the tissues at the angle, and the posterior flap cut from the back of the thigh. The assistant then raises the thigh and retracts the flaps, while the operator prepares the bone for the saw, about an inch and a half above the base of the flaps; it is next divided, with all the usual precautions. As regards the **vessels divided**—(1) The femoral vessels at any point below the middle of the thigh will be found at the inner side of the posterior flap; above the middle of the thigh they will be at the inner side of the bone, and at the upper part they will be in front of the bone. (2) The termination of the deep femoral, towards the outer aspect of the posterior flap, close to the bone. Besides these (3) perforating, and (4) muscular branches may also require ligature. The position of the femoral artery matters but little, provided the operator takes care not to transfix it, which he is very liable to do about the middle of the thigh, but this can be avoided by not going too close to the femur on the inner side, and leaving the vessels to be divided by the circular incision (Heath).

3. **Lister's Method.**—The limb is held as in previous

amputations of the thigh, and the Surgeon stands on the right side of the limb to be amputated, as by so doing he can better raise the flaps with his left hand. He then makes two straight incisions through the skin and fat, along the lateral aspects of the limb parallel with its anterior surface, and each equal in length to two-thirds of the diameter of the limb. At the lower ends they are united by a transverse incision curved upwards at its extremities, where it joins the longitudinal ones. In this way a square-shaped flap is formed with well rounded angles. The knife is then passed round the back of the thigh at an angle of 45 degrees to the axis of the limb, marking out a short posterior *skin* flap; the assistant then elevates the limb and the posterior flap is dissected up at once. By making the posterior flap of skin only there is but little danger of its retracting too much, as it is freed from the hamstring muscles. The anterior flap is next raised, and at first consists only of skin and fascia, but, as the bone is approached, a moderate amount of muscle is included. The assistant now retracts the soft parts, the knife is swept circularly through the muscles so as to expose the bone about two inches above the angle of the flaps, where the saw is applied and the bone divided *secundum artem.*

In amputations through the thigh the following structures are divided, speaking generally :—(1) The integumentary coverings. (2) Muscles—(*a*) The quadriceps extensor cruris, (*b*) sartorius, (*c*) the adductor longus, (*d*) the adductor magnus, (*e*) the gracilis, (*f*) the hamstrings. (3) Vessels—(*a*) Femoral vessels (about this point these will be found at the inner side of the posterior flap), (*b*) the profunda vessels (these

will also be found in the posterior flap, close to the posterior surface of the femur), (*c*) the long saphenous vein. The position of the femoral will vary with the point of section; for, as has already been pointed out, the vessel as it passes down the thigh gradually inclines from the anterior to the posterior aspect of the bone, so that it may be found at some parts in the inner side of the anterior flap. (4) **Nerves**—(*a*) The great sciatic; and also small branches of—(*b*) the obturator, (*c*) the anterior crural, (*d*) the small sciatic, (*e*) the external cutaneous. (5) The femur.

AMPUTATION AT THE HIP JOINT.

As hæmorrhage is one of the most serious dangers of this operation, various measures are employed, or have been suggested, to overcome this danger.

1. **Lister's or Pancoast's Aortic Tourniquet.**—Previously this was the method usually adopted, but, as Lister himself points out, it has two defects—(1) On account of the occasional deviation of the aorta from its median or almost median position, the adjustment of the pad, and its retention when adjusted, is rendered a difficult matter, and it is apt to slip to one side, and in order to prevent this the constant attention of a very trustworthy and steady assistant is required; (2) The Surgeon, especially if inexperienced and nervous, is apt to screw down the pad too tightly and damage the intestines and peritoneum; a soft, hollow sponge placed under the pad will to a certain extent prevent this. It is compressed immediately above its bifurcation, a little above and to the left of the umbilicus, as the aorta bifurcates a little to the left and *below* the umbilicus, or on a level with the highest point of the iliac crests.

2. **Esmarch's Elastic Tourniquet, applied to the Aorta.**—A pad of sufficient size is adapted over the aorta, a little above the highest points of the iliac crests, and pressed down by elastic bands. To avoid circular compression of the body, a narrow piece of board, or some such contrivance, is placed transversely beneath the back and projecting beyond the sides of the body; lateral notches are made in it, or hooks attached to it, at a sufficient distance to protect the sides from compression, and at the same time to serve to fix the elastic bands. Esmarch himself recommends, in absence of any other instrument, the following plan:—A common roller bandage, about two and a half inches wide, and eight yards long, is to be rolled round a stick about the thickness of the thumb, and nine inches long. The pad thus formed is held in proper position by the ends of the stick, while several turns of elastic bandage are passed round the body, so as to press it forcibly against the spine. An assistant keeps the pad in proper position by means of the stick. An OBJECTION to this plan (and all plans) of elastic compression is that, should the patient vomit or cough, the forcible contraction of the abdominal muscles lifts the pad from the aorta and relaxes the compression.

3. **Esmarch's Elastic Tourniquet applied to the Extreme Upper Part of the Thigh.**—The limb is emptied of blood by vertical elevation for a few minutes, and then an elastic band, strong enough to require the whole strength of the Surgeon to stretch it twice its length, is applied. A piece of bandage is first laid upon the middle of the groin in the line of the limb, and a similar piece placed behind, well below the great trochanter, over which the tube is to be

applied. These are to be held by an assistant, who thus prevents the band from slipping downwards over the flaps during disarticulation. The scrotum being held aside, the middle of the tube is then placed against the perinaeum, and the ends pulled forcibly and crossed as high above the trochanter as possible, and afterwards carried round the body immediately below the iliac crests. If the elastic band is applied firmly enough, it is not necessary to have a pad over the artery. This is the method chiefly to be recommended in Jordan's amputation at the hip, joint or its modifications.

4. **Davy's Lever.**—This is used to compress the common iliac artery, as it lies in the groove between the last lumbar vertebra and the psoas muscle. It is a smooth, round, wooden 'lever,' shaped like a poker, and about two feet long. Two ounces of olive oil are first injected, and the lever is then passed into the rectum sufficiently far to permit its point to press the vessel at the spot mentioned, when the other end of the lever is carried towards the thigh of the opposite side and its handle raised, when it acts as a lever, the anus being the fulcrum. Two **precautions** are necessary in the use of this instrument—(1) It must not be used where the coats of the rectum are diseased, as it may easily perforate them and lead to a fatal result. (2) In cases where the meso-rectum is abnormally short it may be impossible, without unnecessary force, to compress the artery on the right side.

5. **Digital Compression** of the femoral artery as it lies on the ilio-pectineal eminence. The assistant stands on the side of the patient on which the vessel is to be compressed, and grasps as much of the limb a

possible with both hands, fixing the tips of the fingers of the one hand below the adductor muscles, and those of the other on the posterior border of the great trochanter, while the thumbs are placed one above the other over the vessel as it lies on the above named prominence of bone. In the antero-posterior flap amputation this assistant must be prepared to follow the knife into the first incision and grasp the flap firmly, so as to compress the femoral artery before the knife cuts its way out.

1. **Antero-posterior Flaps** *(long anterior and shorter posterior).*—The patient must be brought well forwards upon the edge of the table, so that the nates project beyond it, and he is further to be steadied by strong bandages—one passed between the sound thigh and the perinæum and attached to the upper end of the table; another is to be carried across the pelvis, to the lower end, and the sound limb is to be tied to the leg of the table. Three special **assistants** are required—No. **one** has to take charge of the aortic tourniquet; No. **two** compresses the femoral artery against the brim of the pelvis, and follows the knife and secures the artery in the anterior flap; No. **three** takes charge of the limb. A long amputating knife, with a blade at least twelve inches long, is necessary, and it is well to have a pair of lion forceps and periosteum elevators at hand. The doubtful advantages of this method are its simplicity, ease, and rapidity of performance, and, should the patient survive, a shapely stump. Formerly rapidity of execution was chiefly trusted to, to diminish the risk of shock and loss of blood. In many cases the rapidity was surprising; the late Professor Spence states that he has completed disarticulation in one case in *ten seconds*,

in another in fifteen seconds, and even in complicated cases in less than thirty seconds. The landmarks in the operation are the *tuber ischii* and the *anterior superior iliac spine.* In operating upon the *right* leg the operator should stand on the *inner* side of the limb; while if operating on the *left* he ought to stand on the *outer* side—*i.e.*, he always stands on the left side of the limb to be removed. On the *left* side the knife is entered about two fingers' breadth below the anterior superior iliac spine (or almost midway between it and the great trochanter), and carried deeply in the limb, behind the vessels and obliquely across the joint, and, if possible, opening the capsule, keeping the back of the knife *parallel with Poupart's ligament*, and bringing its point out just in front of the tuberosity of the ischium, or immediately below (as the patient lies on the operating table) the ridge formed by the projecting edge of the adductor longus, taking care not to transfix the scrotum, or the opposite thigh, at the same time. If the *right* leg is to be removed, the point of the knife must be entered where it comes out on the left side: that is, it must be entered just above the tuberosity of the ischium and brought out midway between the anterior superior iliac spine and the great trochanter. The remaining steps of the operation are the same as on the left side. Everything being ready, the assistant who has charge of the leg, *flexes it slightly on the abdomen, and, at the same time, abducts it a little and rotates it slightly inwards.* The knife is then entered as already explained, and the anterior flap cut downwards and forwards for about six or eight inches, taking care to keep the flap broad at the point by carrying the knife close to the bone for a considerable distance, and

then bringing it out abruptly at the last; the assistant must on no account extend the limb till the flap is completely cut, and, further, the assistant who has charge of the anterior flap with the femoral artery must not raise the flap at all nor compress it *laterally* till the knife has cut its way out. The leg assistant now *forcibly abducts, extends, and rotates the limb outwards*, while the Surgeon opens the capsule of the joint with the point of the knife and allows the head to spring out of the cotyloid cavity, and then divides the *ligamentum teres*. The assistant next allows the leg to hang downwards so as to bring the head of the femur away from the cavity and put the posterior part of the capsule on the stretch, which the Surgeon also divides with the point of his knife. The assistant again *places the limb in the extended position, in a line with the body, and rotates it well inwards*, so that the great trochanter shall not arrest the knife. The operator then makes the posterior flap by carrying the knife downwards and backwards, forming a flap about four inches in length, or about half the length of the anterior. The arteries in the posterior flap (gluteal and sciatic) often bleed freely and should be at once compressed by dry sponges and tied first, provided the assistant who has charge of the femoral artery has a good hold and is trustworthy.

Mr Heath advises the operator to stand on the *outer* side of the limb in all cases. His objections to transfixing the *right* leg from the inner side are—(1) The danger of pushing the knife through the obturator foramen into the pelvis; (2) he is very much in the way of the assistant who manipulates the limb; (3) the chances of being bespattered with blood, and the certainty of intercepting the view of bystanders.

2. **Single Anterior Flap.**—A single anterior flap is cut as in the last operation, eight or ten inches long; the absence of a posterior flap favours drainage. The different positions and manipulations are exactly the same as in the previous operation, only the knife is carried straight backwards without making a posterior flap.

3. **Lateral Flaps.**—The external flap is raised by dissection; the internal is cut by transfixion. The angles where the flaps meet are—in *front*, the centre of the groin, just external to the femoral vessels; *behind*, just in front of the tuberosity of the ischium. Before making the flaps the skin should be pulled well upwards, and they should be about three inches in length or more, the external one reaching to a point about a handsbreadth below the great trochanter. The external one is then dissected upwards to the level of the upper border of the great trochanter, when the bone is disarticulated and the knife inserted into the anterior angle, passed backwards close to the inner side of the neck of the femur, and brought out at the posterior angle, and a flap, equal in length to the external, formed. The vertical incision favours drainage, but it also favours innoculation of the discharges and wound with germs from the genital and anal passages. Another advantage is that the vessels are cut last—the external flap being raised, and the head of the bone disarticulated before the inner flap is made. In disarticulating forcibly adduct the limb. The position of the limb during the operation resembles the antero-posterior flap method, the leg being held with the buttocks projecting beyond the edge of the table, and the slight differences in the manipulations will readily suggest themselves. For the

inner flap a transfixion knife with a blade a foot long is employed, for the external, a shorter one may be used.

4. **Skin Flaps.**—As in other cases of malignant disease of joints, this method may also be adopted at the hip. Make the skin flap sufficiently long as the skin is very contractile,—six to eight inches both front and back. The great objection to this plan is that all the irregularities have to fill up by tedious granulation, and may not be thoroughly healed for years.

5. **Furneaux Jordan's Amputation.**—The soundness of the principles of this method has already been fully demonstrated in practice, and at the present time the whole question of amputation at the hip joint has been revolutionised. The days of the old classical flap methods are numbered. But in the case of malignant disease with infiltration of the soft parts JORDAN'S method cannot be adopted, and skin flaps must be used instead. The **principles** of the method are—(1) To enucleate the femur by an incision through a part where it is most thinly covered by soft textures, and where the blood vessels are small and few. (2) To cut across the limb where it is smaller and further removed from the trunk and to interfere as little as possible with the bulky soft parts at the *upper and inner part* of the thigh. Either the one or the other of these two steps may be done first—that is, we may either divide the soft parts circularly low down the thigh, and then dissect out the bone through a long incision on the outer aspect of the limb, or else dislodge the head of the femur first from the acetabulum, separate the shaft from the soft parts and cut across the soft parts last and low down—according to the taste of the operator. Probably the

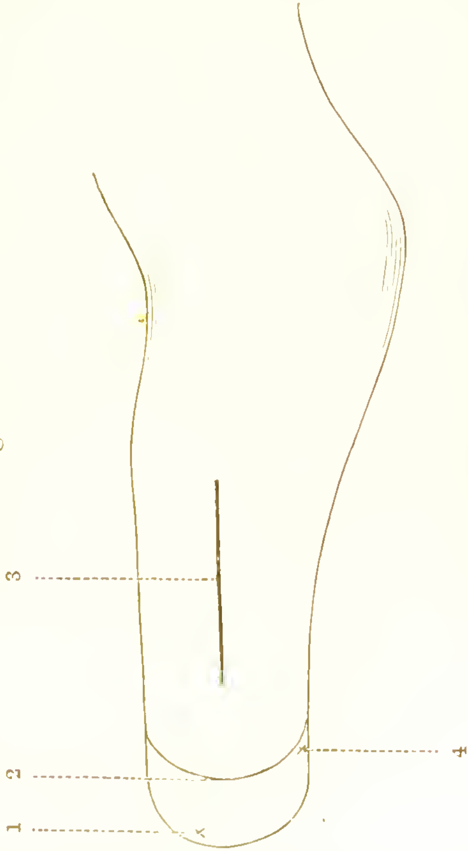
best way is to divide the soft parts and bone circularly low down, then tie all the vessels, turn the patient over to the sound side, and remove the head and upper part of the shaft of the femur through the vertical incision on the outer aspect of the limb. In this case the leg is held projecting from the buttock over the edge of the table, slightly flexed or horizontal. Another assistant pulls the integuments well upwards, while the Surgeon encircles the limb by one sweep of the knife through the skin, fat, and fascia; the skin and fat are then dissected upwards a little way, and the muscles divided by another circular sweep of the knife down to the bone, which is sawn on a level with the muscles. All the vessels are then secured, the patient turned over to the sound side, the bone disarticulated and dissected out through the vertical incision. As this operation is usually performed for late hip disease, the disarticulation, as a rule, is easy. Should, however, any difficulty be experienced the bone should be adducted to the greatest possible extent and the great trochanter seized with a pair of lion forceps and dragged forcibly outwards.

In the other case the patient is at once turned to the sound side, and a free vertical incision is made along the outer side of the thigh from the top of the great trochanter, six inches or more in length. Dislodge the head of the femur, and then separate the upper part of the shaft from the soft structures by a few longitudinal strokes of the knife, the edge of which must be kept close to the bone; the bone is thus cleared as far as may be deemed necessary. It is next replaced in its bed till the soft parts are divided at any level thought desirable by circular sweeps first through the skin and

then the muscles; then secure all the bleeding vessels, and closely stitch up the lower part of the wound and insert a drainage tube at the lower and outer angle. It is always advisable to save the periosteum if possible, so that the muscles may still retain their attachment, and besides, a central rod of bone may be produced, which will render the stump firm, and give the patient some amount of control over an artificial limb. It must be remembered, however, that in the later stages of hip disease the periosteal hæmorrhage may be free and difficult to check. There is no doubt that Jordan's amputation is very much more difficult and tedious than the old antero-posterior flaps by transfixion; but this is of little moment when one considers the increased safety. As performed in the way above described, there is sometimes a little difficulty in making the skin surfaces meet neatly over the muscles, and especially at the point where the vertical incision joins the circular, where two sharp corners are formed. Instead of dividing the skin circularly, could it not be divided after the manner of the '*modified circular*' method, the skin flaps being *internal* and *external*, and the internal at least twice as long as the external, and that the vertical incision should not be prolonged to the apex of the external flap (Fig. 20), but stop two or more inches short of that point? The lower end of the bone could easily be freed by a circular sweep of a sharp-pointed, straight bistoury, carried parallel with its shaft, or shelled out by a periosteum elevator without prolonging the incision to the apex of the flap; and besides the skin is retracted for one or two inches before the muscles and bone are divided. The skin flaps are first made and retracted from one to two inches, the muscles and bone are then

divided circularly, and all the vessels tied; the patient is then turned over to the sound side, the head of the femur dislodged and dissected out through the vertical incision. The large internal flap is folded over the end of the stump to meet the external; the wound can thus

Fig. 20.



AMPUTATION AT LEFT HIP JOINT.

1. Internal flap, longer than the external. 2. External flap. 3. Incision through which the head and upper part of the shaft of the bone is enucleated. 4. Angle for drainage tube.

more easily be kept aseptic, and the bridge of skin will simplify apposition of the edges, and bind the large muscular masses together, especially those at *the upper and inner part of the thigh*, which are apt to fall apart

and increase very considerably the surface of the wound (Fig. 20), so that instead of being *less* than in the flap method it is actually *greater*.

The advantages of Jordan's method are—(1) the cut surface is less; (2) the large nerves are cut further from the trunk; (3) shock is immensely diminished; (4) it can be kept aseptic, as the wounded surface is further from the rectal and urinary passages; (5) union should be more rapid; (6) it may be done subperiosteally; (7) there is no need for hurry on account of any danger from hæmorrhage; (8) the vessels are cut transversely, and not obliquely as in the flap methods; (9) the stump is much longer than in the ordinary flap operations, and it is more easy therefore to fit an artificial limb to it; and, should the subperiosteal plan be adopted, the stump is firm and the patient will possess a considerable amount of power over the artificial substitute: (10) in cases of doubt the Surgeon can make the vertical part of the incision first, examine the joint, and, if too bad for excision, convert it into a 'JORDAN,' just as in SPENCE at the shoulder, and CARDEN at the knee joint. The only disadvantage is that it is more difficult and tedious to perform than the ordinary flap amputation.

In Mr BECK's hands the method assumes the form of the oval or 'RACKET-SHAPED' amputation, which he performs thus:—The patient is placed on his sound side with his hips close to the edge of the table; the sound thigh is to be flexed as far as possible, and secured in that position by two bandages, one attached to the thigh immediately above the knee with a clove hitch, the two ends of which are passed round the patient's neck, and under the arm of the same side, and firmly knotted; this maintains the flexed position and steadies the trunk.

The other is also passed round the sound thigh and secured to the leg of the table beneath the patient's *head*, in order to prevent him slipping down during the operation. Secured thus his body is further steadied by an assistant placed opposite the shoulders; another assistant has charge of the thigh, which he grasps above the knee and holds slightly adducted, and a third, standing opposite the Surgeon, has to grasp the femoral artery by thrusting his hand into the wound and securing it between his fingers and thumb before it is divided. The Surgeon stands behind for the right thigh, and in front for the left, so as to grasp the flaps with his left hand; he should further be provided with a moderate-sized amputating knife, the blade being about six inches long. On the *right* side the incision is commenced about two inches above the great trochanter, and carried down to the bone and along the shaft for six or seven inches below the trochanter, and at this point the incision is made to bifurcate passing respectively forwards and backwards for about two inches, so as to mark the point where the 'oval' is to surround the thigh. The assistant now abducts the limb, and the operator pushes his thumb into the slit made in the two smaller glutei, which he stretches, and with the point of the knife he separates the muscles from the trochanter and upper part of the femur, first in front and then behind. The assistant next forcibly adducts the limb, and at the same time tries to lift the head of the femur out of its socket, by placing one of his hands on the inner side of the thigh, as high up as possible. The Surgeon then opens the joint by making a free cut in the line of the first incision, so as to slit open the capsule and divide the cotyloid ligament, and then carries the knife along

the posterior attachment of the capsule. The head of the bone should now spring out of its socket, but if not it may be dragged out by seizing the great trochanter with a pair of lion forceps; the round ligament is next divided. The anterior part of the capsule is then cut, the knife passed over the head of the bone, and the assistant then grasps the trochanter and pulls the bone forcibly out of the wound, while the operator holds the soft parts out of the way with his left hand, and passes his knife along the inner side of the femur, freeing the bone from the soft parts as low as required. All this time the limb must be in a position of extreme adduction. When the bone is cleared as far as necessary, it is replaced in its bed, and the limb brought into a straight line with the trunk, and the Surgeon completes the skin oval and dissects up the skin, fat and fascia, for two or more inches, especially in very muscular limbs; another assistant then places his hand in the wound and grasps the femoral artery, while the muscles are divided and the leg removed. If preferred, the skin oval may be completed and dissected up the necessary distance, before the head of the bone is dislodged. On the *left* side the only difference in the operation is, that the straight incision is made from below upwards.

In amputations through the hip joint the following is a list of the chief structures divided—(1) The integumentary coverings. (2) Muscles—(*a*) Pectineus, (*b*) the three adductors, (*c*) the gracilis, (*d*) the sartorius, (*e*) the tensor fasciæ femoris, (*f*) the upper part of the quadriceps extensor cruris, (*g*) the obturator internus and the two gemelli, (*h*) the obturator externus, (*i*) the pyriformis, (*j*) the three hamstrings (the biceps, semi-tendinosus, and the semi-membranosus), (*k*) the

three glutei muscles, (*l*) the quadratus femoris, (*m*) the psoas and iliacus. (3) **Vessels**—(*a*) The long saphenous vein, (*b*) the femoral vessels (in the anterior flap), (*c*) the sciatic vessels, (*d*) the gluteal vessels (the gluteal and sciatic vessels are found in the posterior flap). (4) **Nerves**—(*a*) Branches of the anterior crural, (*b*) branches of the obturator, (*c*) the great sciatic, (*d*) the small sciatic, (*e*) the external cutaneous, (*f*) branches of the superior gluteal. (5) **Ligaments**—(*a*) The capsular ligament, (*b*) the ligamentum teres, (*c*) the ilio-femoral band.

CHAPTER XVIII.

EXCISION OF JOINTS.

I. **Excision may be required for** (1) Injury, as bad compound dislocations, fractures into joints, more especially gun-shot injuries of the head of the humerus, bones of the elbow joint, and head of femur. (2) For disease of various kinds—(*a*) To *remove the diseased part* in cases where amputation is not justifiable, as in some cases of hip joint disease, and disease of the temporo-maxillary articulation. (*b*) To *save life* where the patient is being exhausted by the discharge and pain, and unless relieved will probably die. (*c*) Merely to expedite recovery and save the patient months or years of suffering. (3) For the results of disease or injury, as in osseous ankylosis of the elbow, or of the knee joint in a bad position.

II. **The Objects aimed at** are—(1) Complete removal of the diseased part. (2) To leave a useful limb; in the upper extremity by securing mobility, in the lower by procuring ankylosis, in order to give a firm basis of support. This is subject to occasional variation to suit the special occupation of the individual, *e.g.*, a house painter requiring his arm fixed in the straight position, a turner his knee fixed at a right angle, so as to allow him to work the treadle (Bryant).

III. **Excision *versus* Incision.**—In cases where there

is no evidence of disease of the bone, but the joint is full of pus, then a free incision and drainage is the proper course; this relieves tension and may cure the disease, but, of course, leaves a stiff joint. Sometimes incision, and scraping away the diseased textures with a sharp spoon, and insufflation of iodoform, and thorough drainage, and strict antiseptic dressing, may give a very good result, *e.g.*, in the ankle joint.

IV. **Excision *versus* Expectancy.**—(1) Consider the possibility of natural cure. A large and important joint ought not to be rashly excised if such a possibility exists. It is especially advisable to wait, in the upper classes, who can procure all the benefits of the best medical skill and attendance, good food and good nursing; with hospital patients, however, the case is different, and probably excision will prove the kindest and best treatment. It is also advisable to wait in cases where the disease is *local* and the general health good. (2) Consider the possible result of a natural cure. The great drawback to the 'expectant' plan is the prolonged course of the disease, perhaps for months or years, and often at the end of that time the patient is little better, or even worse, than had an operation been performed and from which he would probably have recovered in a few weeks. Hence we must carefully place before the patient the two possible alternatives—speedy cure but with the risk of the operation, opposed to prolonged illness and risk of exhaustion and in the end a useless limb. In the case, however, of the wrist joint the case is a little different (see excision of wrist).

V. **Excision *versus* Amputation.**—(1) *The comparative risk of the two operations.* Excision makes a

larger wound, and therefore a greater strain on the constitution and a larger surface for septic absorption; hence in advanced disease of the joint with abscesses around it, and discharging sinuses, it is better to amputate as it would be a difficult matter to make and keep the wound aseptic. (2) *As regards the joint affected*, and the advantages of the limb left, over an artificial substitute. Excision is safer than amputation at the *shoulder;* at the *elbow*, the danger is nearly equal, but the probability of saving a useful arm and hand throws the weight on the side of excision. So also at the *wrist*, excision is to be preferred to amputation. At the *hip*, excision is very much safer; at the *knee*, excision was formerly more dangerous than amputation, but thorough drainage with the present antiseptic methods of treating wounds have done much to lessen the mortality. At the *ankle*, amputation (SYME'S) is a less severe operation, and will probably give the most satisfactory result in every way. Hence excision of the ankle is but rarely performed, except of course in cases of injury, where the broken fragments may be removed, the joint rendered thoroughly aseptic, and the rest left to nature. In the upper extremity therefore usually excise, using every possible endeavour to preserve a movable elbow, wrist, and thumb; in the hip, wait, or if that is not advisable, excision is immensely preferable to amputation. But sometimes amputation is necessary in the case of prolonged and exhausting disease to give the patient a chance for his life, and the present improved method of amputating the hip joint has robbed that operation of many of its former most serious risks. (3) *As regards the disease.*— Excision should never be performed for malignant

disease, nor in advanced cases of gelatinous degeneration, with abscesses round the joint and pus burrowing up and down the limb. It should not be done either in the *acute* stages of the disease; in such a case rather trust to a free incision with antiseptic precautions and drainage. It is chiefly indicated in disease of the cartilage, and limited disease of the bone. 'The most appropriate cases for the excision of joints are those of chronic disease of all the tissues *(white swelling)*, in which the bones are probably not affected to any great depth' (HOLMES). It has been occasionally performed for chronic rheumatic arthritis; but in this disease, to say the least, it is not a *necessary* operation, in the sense of saving life, and it should not therefore be pressed upon the patient, and besides it is rare to find a *single* joint affected with this disease. It is also performed for cario-necrosis of the articular ends of bones, but the loose part may simply be removed and the joint left to ankylose, except in the case of the elbow where ankylosis is objectionable. In diffuse caries of the hip wait, even though slow, unless other indications point towards excision or amputation. When the soft structures only, round the joint are affected excision is very rarely required, as a useful limb will probably result without operation of any kind. (4) *As regards the general health and social position of the patient*, in reference to the comparative risk of a long or short after treatment; whether or not he is worn out by exhausting disease, and also if free from constitutional taint such as struma, syphilis, &c. Consider also the facilities for after treatment and the time and attention required; the knee joint, for example, will require great care and repose for many

months; also the temperament, whether irritable or otherwise.

VI. **A Typical Case.**—Where the Surgeon may reasonably hope for a successful result, may be regarded as something like the following:—(1) *The disease should be limited;* this is especially necessary in the lower extremity, as removal of a considerable portion of the bones here would render the limb less useful, or altogether useless, and would entail a severe operation. Further, in young persons, unless the disease is limited the epiphysis will be interfered with and result in arrest of development of the limb. In the upper extremity, however, length and strength are of less consequence. (2) *The patient should be constitutionally healthy,* not worn out by cachectic conditions of any kind, or waxy disease of internal organs. Under these conditions amputation would be safer. (3) *The joint affection should be the result of accident,* and not due to constitutional taint. (4) *The disease should be chronic.* Disease should not be interfered with during the acute stage, because (*a*) one cannot foretell the probable natural result as the disease subsides. It is possible that as useful a limb will be left by nature as the Surgeon could hope to obtain by excision; secure absolute rest, drain if necessary, keep in proper position for ankylosis, and wait. (*b*) Another objection to operation during the acute stage is the risk of setting up septic inflammation of the medullary cavity, or cancelli, with the usual results of osteo-phlebitis, thrombosis, septic embolism, pyæmia, and death. (5) *The soft parts around the joint should be healthy.* They should not, for example, be permeated by discharging sinuses. Should they be much infiltrated and dis-

organised it would be useless to hope for healing of the wound; this has especially to be considered in the case of the knee and ankle. In other cases, the elbow, for example, the incision may be made so as to include the different sinuses even though not made in the orthodox position and direction; sometimes also the sinuses may be used as drainage apertures, after freely scraping them with a sharp spoon and brushing them with a solution of zinc chloride (20 to 40 grains to the oz.), or some other antiseptic. (6) *The patient must not be too young or too old.* The most suitable age is from 20 to 30. If too young, even though other conditions are favourable, the epiphysis might suffer, and the development of the limb be arrested to a great extent in consequence, as it is at this part that the development of the bone in length is mainly dependent. In reference to this, Mr HUMPHREY has pointed out that all epiphyses are not of equal importance: he states that the upper epiphysis of the humerus and tibia, and the lower epiphysis of the femur and radius are the most important as regards the growth in length of the respective limbs. If too old the patient's constitution is unable to bear up against the severity of the operation and the protracted convalescence. (7) The Surgeon should have *proper means* at his disposal *for after treatment*, and a restful, trustful, hopeful patient.

VII. **In Performing the Operation.**—(1) Make the *incisions* parallel with the axis of the limb, so that the cicatrix will not interfere with the movements of the joint afterwards; again, by making the incision thus, we will usually avoid dividing important structures, as blood vessels, nerves, and tendons. At the same time the incision must be sufficiently *free* to expose the

parts to be removed. In cases where a movable joint is the object, division of muscles and tendons must be avoided as far as possible. (2) *Remove as little of the bone as possible*, consistent with the object in view. The gouge may be used to scoop out carious cavities, in preference to making a complete transverse section of the bone again. At the same time, if too little bone be removed in the case of the elbow joint, the risk of bony ankylosis is very great (SPENCE). But in the case of the knee joint, where the object is ankylosis with the least possible amount of shortening, then remove as little as possible. (3) In cases where a movable joint is the object *save the periosteum and capsule* of the joint, provided they are healthy. (4) In cases of 'pulpy disease' of the synovial membrane all the diseased textures must be carefully *scraped away* with a sharp spoon, and all sinuses must be very freely scraped and ascpticised and provision made for thorough drainage, and the whole dressed with strict antiseptic precautions. (5) The *special splints* and attention to procure movement or absolute rigidity will be mentioned under the special excisions.

VIII. **Instruments Required.**—I will only mention the special and more important instruments necessary in this list. (1) *Scalpels and bistouries*, thin and stout bladed, strong backed and sharp pointed, and occasionally a blunt pointed one is useful—the sharp pointed are used for making the incisions, and the blunt pointed one used afterwards, as in shoulder and hip excisions. (2) *Saws of various kinds.*—(*a*) Butcher's, which has a narrow blade that can be adjusted to any angle, so that it runs easily and in any direction; it is especially suitable for the elbow, or in cases where it is

desirable to cut the bone obliquely and where the space is limited. (*b*) A broad-bladed, strong, movable-backed amputating saw, such as Fergusson's, should be preferred in excision of the knee joint, where the bones are easily reached and a broad slice has to be removed and in a special direction. (*c*) A chain saw is occasionally of use in dividing deep-seated parts, as in the hip joint. (*d*) A 'key hole' saw. (3) *Broad curved copper retractors.* (4) *Gouges*, to scoop out carious cavities after section, and thus economise length of bone. (5) *Lion forceps* (FERGUSSON'S) to hold firmly the piece of bone to be sawn off. (6) *Cutting pliers and gouge forceps.* (7) *Periosteum elevators.* (8) *Excision director* in cases where the bone cannot be turned out of the wound. (9) *Volkmann's sharp spoon.* (10) *Esmarch's elastic tourniquet* to prevent bleeding during the operation. To this list might be added—artery forceps, sutures, needles, dressings, splints, awl, for 'wiring' bones, drainage tubes, &c.

CHAPTER XIX.

SPECIAL EXCISIONS.

SHOULDER.

Excision of the Shoulder Joint.—Various forms of incisions have been proposed—(*a*) A single longitudinal vertical incision; (*b*) a **T**-shaped incision; (*c*) a modification of this form, one half of the cross bar being omitted—somewhat like the letter **L** upside down: these two forms are chiefly used in cases where the soft parts are much infiltrated and non-resilient, and where, consequently, it is necessary to gain more room, which is done by making a short cross-cut at one or both sides of the longitudinal incision; (*d*) the **U**-shaped deltoid flap operation.

To **check hæmorrhage** during the operation an assistant may compress the subclavian by a padded key, or Esmarch's elastic tourniquet may be used. The elastic band is forcibly stretched, and applied round the shoulder, and as high up in the axilla as possible, so as to compress the artery against the neck of the scapula; the upper part of the turn should rest in the concavity at the outer end of the clavicle and internal to the coracoid process. To prevent its slipping during the operation, pieces of bandage should be placed beneath it, both in front and behind, and held by an

assistant at the opposite shoulder. Excision may be required for—(1) *Disease,* as caries of the head of the bone, simple and tubercular, disease of the cartilage, &c.; in these cases the glenoid cavity is *secondarily* involved, and will recover without interference, when the head of the bone is removed. (2) *Injury,* as compound and comminuted fractures, gun-shot wounds, &c. (3) *Results of disease or injury* rarely demand excision of the shoulder; many diseases end in ankylosis, either true or false, but for this condition excision is but rarely indicated—(*a*) because, on account of the weight of the arm, it usually ankylosis in the best possible position; (*b*) even when ankylosed in a not very favourable position the mobility of the scapula, to a great extent, compensates for the loss of movement of the joint itself; besides, the amount of movement obtained after excision is often not so great as in cases of ankylosis by disease.

1. **By the Single Longitudinal Vertical Incision.**—In connection with this incision, it should be noted that the posterior circumflex artery, which passes round the posterior aspect of the surgical neck of the humerus, though large at first, becomes very rapidly smaller; and therefore the incision should be towards the anterior part of the joint, in order to avoid wounding either the trunk of the vessel or its larger branches, and thus lessen hæmorrhage during the operation. **Position of the patient.**—He is to be placed on his back, with the shoulder to be excised raised and projecting a little beyond the edge of the table, and held by an assistant slightly abducted. The **operator** stands facing the patient, and on the same side as the joint to be excised. Begin the **incision** a little to the outer side of

and above the coracoid process, and carry it downwards and a little outwards through the anterior part of the deltoid, immediately external to the cephalic vein, which must not be injured, for about four inches, down to, but not through, the insertion of the pectoralis major. The incision must go right down to the bone. By this incision (1) the integumentary structures and (2) the deltoid are divided. Draw aside the edges of the wound with blunt hooks or copper spatulæ, feel for the bicipital groove, and then make a longitudinal incision through the periosteum, along the inner side of the groove, to the glenoid cavity. The long tendon of the biceps may then be raised from its bed and drawn to the outer side. The assistant then rotates the humerus forcibly outwards, while the Surgeon separates the tendon of the subscapularis and periosteum from the head of the bone with a periosteum elevator. The long tendon of the biceps is now to be shifted to the inner side, and then the assistant rotates the humerus inwards and allows it to fall over the edge of the table, when the Surgeon separates the periosteum and muscles attached to the greater tuberosity—the supra-spinatus, infra-spinatus, and teres minor—in the same way that he separated the tendon of the subscapularis. The assistant next forces the head of the bone up into the wound, by drawing back the elbow and pushing upwards, when the Surgeon separates the posterior part of the capsule with the periosteum elevator, keeping in mind the near presence of the posterior circumflex artery and the circumflex nerve, and carefully preserving them from injury; the Surgeon himself then takes the arm from the assistant, pushes the head of the bone out of the wound, while the assistant draws the soft parts well

aside, and saws the bone by a Butcher's saw, with reversed blade, through the surgical neck. In cases where the head of the bone is severed from the shaft by injury or disease, it must be seized with a lion forceps and carefully dissected out. As this operation is usually practiced for disease, the periosteum, softened by the inflammatory action, is readily separated from the bone. Should, however, any great difficulty be experienced in doing so, the capsule must be divided close to the anatomical neck of the humerus, along with the tendons attached to the tuberosities. The glenoid cavity is next examined, but it rarely requires to be interfered with at all. If very much diseased, it may be removed or dressed by the gouge-forceps through a posterior vertical incision. above the posterior circumflex artery. This may seem an unnecessary mutilation, but, as a matter of fact, it is not so, as this opening can be afterwards utilised for drainage, and, besides, the glenoid cavity is much nearer the posterior than the anterior surface. In cases where the glenoid cavity is not interfered with a counter opening must be made behind for the exit of discharges, since the patient lies on his back, and were no opening made the wound would simply become a huge well of putrescible fluids, and a fit nidus for the growth of putrefactive organisms. To make the opening, bring the arm to the side, into the same position it will occupy during the after treatment, and by means of a dressing forceps (Mr SPENCE used his left index finger), work through the tissues till its point presses against the skin, above the posterior circumflex artery; divide the skin over the point of the forceps, push it through, open the blades, seize the drainage tube and withdraw it, leaving the tube in its

proper place. This care is necessary, on account of the presence of the large posterior circumflex artery.

As regards the **after treatment** no special apparatus is required, all that is necessary is to support the shoulder on a pillow for a few days, with a good, long, soft pad, thicker above than below, placed in the axilla to keep the upper part of the shaft outwards, as it is apt to be tilted inwards by the muscles inserted into the bicipital groove—pectoralis major, latissimus dorsi, and teres major—just as in fracture of the surgical neck. When the patient is able to sit up and move about (which he should be encouraged to do as soon as possible), the arm is to be supported by a sling, and the elbow allowed to hang freely down (BELL). He may be allowed to move about, the elbow being carefully supported (HOLMES). In any case it must be gradually brought into useful motion, first passive, and then voluntary. The **advantages** of the longitudinal incision, in this position, are—(1) The deltoid muscle is not injured to any extent, and will therefore be of great service after the wound has healed. (2) The posterior circumflex artery is not divided, except a few of its terminal twigs, and therefore the hæmorrhage is not great. (3) If the joint is too bad for excision the wound is easily transformed into a Spence's amputation. The only **disadvantage** is that it is rather more difficult to perform than by the next incision.

After excision the arm can never be raised beyond a right angle; flexion, extension, and adduction are usually free, but rotation is, as a rule, permanently lost. The amount of abduction will necessarily depend on how the operation has been performed; if by the deltoid flap, then it will be greatly diminished. The

length and strength of the arm are of little consequence, so long as it is able to be a useful servant to the *hand*, which is the chief point to be considered in all excisions of the upper extremity.

2. **By the U- or rather V-shaped flap,** with the base upwards, from the deltoid. The **incision** is commenced at the posterior border of the acromion process, and carried across the line of insertion of the deltoid, and terminates at the outer side of the coracoid process.

The flap thus marked out is raised; if possible, save the periosteum and tendons, as in the last operation, by making a longitudinal incision on the outer aspect of the capsule and head of humerus, and raising the periosteum and tendons *en masse* by an elevator. In doing this the arm should be brought across the chest. The bone is sawn, the glenoid cavity examined as in the last method, and after this the flap is replaced and retained by sutures, and a drainage tube inserted behind. The **disadvantages** of this method are—(1) the great mutilation of the deltoid muscle and consequently a much less useful arm is left; (2) the division of the trunk of the posterior circumflex artery and in consequence more severe haemorrhage than by the other method. Its only **advantage** is that it is more easily performed than by the single longitudinal incision. In some cases it may be advisable to excise the joint **from behind,** through a vertical incision, especially where the tissues behind are involved in the diseased action, but those in the front comparatively sound. The difficulty is, of course, the small space at the disposal of the Surgeon in making the vertical incision, without dividing the posterior circumflex artery, and perhaps the circumflex nerve as well.

THE ELBOW JOINT.

Excision of this joint may, just as the shoulder, be required for—(1) *Disease*, chiefly strumous arthritis: in young subjects chiefly affecting the synovial membrane; in older subjects, chiefly affecting the bone, and at first the ulno-humeral articulation, the radius being usually the last bone to be affected. (2) *Injury*—as compound and comminuted fractures, compound dislocations, and gun-shot injuries. (3) For *results of injury or disease*—as osseous ankylosis, whether straight or angular. In most other joints excision should not be performed while there is hope of a cure by ankylosis, but in the elbow joint it is different, and every effort must be made to secure a movable articulation. In cases, however, of ankylosis of the elbow at a right angle, the joint is wonderfully useful; I have seen a case (a medical practitioner) where it was almost impossible, without close scrutiny, to tell the difference. To control hæmorrhage during the operation, empty the limb of blood by vertical elevation and apply ESMARCH's elastic tourniquet over the upper part of the brachial artery.

Position of the Arm.—An assistant, standing on the side opposite the diseased limb, grasps the arm above and below the elbow, keeps it moderately flexed and raised from the body and carried somewhat across the patient's chest, so as to thoroughly present the posterior aspect of the joint to the Surgeon. If more convenient this assistant may stand at the shoulder of the same side, instead of on the opposite side. The patient should be slightly inclined to the opposite side, the diseased side being raised by pillows. The Surgeon,

of course, stands on the same side as the joint to be excised, facing the patient. It may be performed by three different forms of incision: (1) The **H**-shaped incision (SYME); (2) another, which is simply the **H**-shaped incision *minus* one of its upright bars; (3) a single longitudinal vertical incision (LANGENBECK), (in this case it is the **H** deprived of one of its vertical limbs and also the cross-bar).

1. **By the Single Longitudinal Vertical Incision.**— This is the form most frequently adopted. The arm being held in the position just described, begin the incision in the middle line, two and a half inches above the elbow, and carry it downwards and a little outwards over the olecranon process and upper part of the ulna, ending two and a half inches below the joint. If preferred the incision may be made a little nearer the inner side, because of the presence of the ulnar nerve, and especially where it is intended to clear the inner condyle first. The upper part of the incision is carried firmly down to the humerus so as to divide the tendon of the triceps longitudinally; the lower part exposes the subcutaneous ulna. The assistant now extends the elbow joint while the operator inserts his left thumb into the wound, to make the triceps tense and peels it and the other structures on the outer side—the common tendon of the extensors and the anconeus muscle—from the outer condyle of the humerus and head of radius. In doing this the edge of the knife must be kept close to the bone and rasping against it. In cases where, in excision for disease, the periosteum is swollen and loosened by inflammation, this separation should be accomplished by means of a periosteum elevator, the periosteum and tendons being

raised *en masse.* By this means the outer condyle and the head of the radius are cleared; by clearing the outer side first the tension is lessened and the operator can more easily deal with the structures at the inner side of the joint among which is the ulnar nerve (SPENCE). Many Surgeons prefer to clear the inner side of the joint first. Mr MAUNDER pointed out that in clearing the outer side it is important to preserve the fascia over the anconeus which is continuous with the tendon of the triceps and attached to the posterior border of the ulna, so that the power of extension of the elbow joint may be preserved. In like manner the inner side of the joint must be cleared, first turning off the triceps and then the rest of the soft parts lower down—the common tendon of the flexors and pronator radii teres—till the inner condyle is fully exposed. In doing so the periosteum elevator should if possible be used, but if not the edge of the knife must be kept close to the bone and carefully follow all its sinuosities so that the ulnar nerve, which lies between the internal condyle and the olecranon process, may escape injury. The flaps are now to be held aside with blunt hooks, and then the assistant must again moderately flex the elbow; the olecranon process is then seized with the lion forceps and the operator snips it off with the bone pliers. The assistant next forcibly and fully flexes the joint till the forearm touches the upper arm, and then holds them vertically at right angles to the table, and at the same time he pulls the forearm towards the table and pushes the humerus upwards; the Surgeon then with a touch of the knife divides the strong lateral ligaments. The condyles of the humerus are then to be cleared and divided by a

Butcher's saw; as before, the outer is cleared first and then the inner, keeping in mind the presence of the ulnar nerve. In sawing the humerus grasp the part to be removed with a lion forceps to steady it, and make the line of section parallel with the lie of the articular surfaces; the section should pass through the olecranon and coronoid fossæ and the widest part of the condyles. The assistant then forces the bones of the forearm out of the wound, the orbicular ligament is completely divided, and the ends of the bones cleared by the knife or elevator till the articular surfaces are thoroughly exposed; the head of the radius may now be divided by the bone forceps, and the rest of the ulna removed by the saw—or the ulna may be grasped by the lion forceps and both bones sawn together, the section including the greater and lesser sigmoid cavities of the ulna. The order therefore of bone division in this excision is—(1) The olecranon process; (2) the lower end of the humerus; (3) the head of the radius; (4) the rest of the ulna. The position of the ulnar nerve at the inner side must never be let out of mind, especially during clearing of the inner condyle and final division of the ulna; the brachial artery is not in great danger, the brachialis anticus muscle lying between it and the wound. In clearing the bones of the forearm it may be necessary to partially separate the insertion of the brachialis anticus into the base of the coronoid process of the ulna, but its insertion should not to any great extent be interfered with; the biceps tendon, inserted into the tubercle of the radius, is not, of course, touched at all. In this operation the following parts are divided—(1) The integumentary structures; (2) the separation of the muscles mentioned

from the bones; (3) the ligaments of the joint; (4) humerus, radius, and ulna; (5) the following vessels, which require to be ligatured:—(*a*) Branches of the superior profunda, (*b*) branches of the inferior profunda, (*c*) the anastomotic branch, (*d*) the radial recurrent.

For the purpose of **drainage** a tube must be introduced well into the wound, and its lower end brought out at the lower angle of the incision; in cases where there is a sinus on the inner side of the joint, it should be utilised for drainage, and the whole of the longitudinal incision stitched up closely.

After treatment.—In excision for *disease* we must guard against ankylosis. After the operation the wound is encased in a thick wrapping of antiseptic dressing, slightly flexed and laid on a pillow, no splints being required. Sometimes it is found to be more grateful to the patient to place it in the extended position with a *light* weight attached to the wrist, to prevent the bones coming into actual contact. Mr Duncan strongly recommends this plan as the best preventive against ankylosis, the weight being just sufficient to steady the parts, and not to separate them too widely; nor must it be used too long lest the opposite extreme be reached, and a 'flail-like' joint result. It is kept thus for ten days, and at the end of that time the weight is removed every morning, and the arm flexed as far as the patient can comfortably bear it, and left thus till night, when the weight is again re-applied. By the end of three weeks the hand should be able to touch the patient's nose, back of head, &c. If the weight is not employed, after the first inflammatory symptoms have passed off, and union by the first intention taken place,—say at the end of a week, or ten days—passive

movement should be commenced, at first merely altering its position from day to day—flexed one day, extended the next, and so on. Later, however, the movements must be more extensive and pronation and supination added. When the patient is able to leave his bed, which he should be able to do in a few days, the arm must be carried in a sling midway between pronation and supination, the thumb uppermost. The after treatment of excision for *injury*, however, differs somewhat from the above, because the great danger in this case is the possibility of a useless 'flail-like' joint, especially in cases where much bone has been removed and the periosteum has also been destroyed. An angular splint, with a joint opposite the elbow, will be necessary so as to keep the parts at rest and yet allow sufficient passive flexion and extension. Pronation and supination must also be attended to, but for this purpose the splint will require to be removed.

The amount of bone removed in excision for disease should not be too meagre, lest osseous ankylosis result. The whole condyloid extremity of the humerus should be removed, the saw passing through the olecranon and coronoid fossæ, but at the same time taking care to leave the broadest possible osseous surface; the greater and lesser sigmoid cavities of the ulna should be removed, as well as the head of the radius. *Partial* excision for *disease* is not good, as it is apt to result in osseous ankylosis, or else in a return of the disease; for *injury* it is often unsuccessful and more dangerous to life. In disease there is but little danger of a 'flail-like' joint resulting. It is never thought necessary now-a-days to resort to the barbarous proceeding, formerly much in vogue in the early days

of joint excision, of moving the joint like a pump handle several times a day immediately after the operation. This is an excessively painful proceeding and the patient would at such times render the wards hideous by his yells; but apart altogether from this, the results of this plan of treatment were often very unsatisfactory—in some cases being ankylosis, in others a 'flail-like' joint. Instead of using the weight and pulley to steady the parts and keep the muscles from pressing the bony surfaces together, *e.g.*, in excision of the elbow joint, Professor CHIENE attains the same object by a box-like splint of sheet lead, outside the ordinary dressings, into which the arm is laid, the whole being fastened by a few turns of bandage. The **advantages** of this form of incision are—(1) It avoids transverse division of the triceps, and therefore the action of this muscle as an extensor is preserved: (2) it further avoids a transverse cicatrix behind the joint, which is apt to interfere with flexion of the joint; (3) recovery is more rapid, provided the wound is well drained; (4) as there is no transverse cut, passive movement can always be commenced early. A **disadvantage,** sometimes mentioned, is that it is more difficult to drain thoroughly.

2. **In the H or the ⊢ forms,** an incision is made three inches long, parallel with the axis of the limb and a little way to the outer side of the ulnar nerve, then a transverse incision from the inner margin of the olecranon (joining the upright one at this point) to the articulation between the outer condyle of the humerus and the head of the radius; this is the ⊣-shaped form, and, if we make another longitudinal incision at the outer end of the transverse one, we complete the first

form of incision—the **H**-shaped form. The chief **objections** to these forms of incision are—(1) The transverse division of the triceps and the transverse scar afterwards interfering with flexion; the division of the muscle itself lessening or destroying its power as an extensor. (2) If the transverse cut fails to heal by the first intention, passive motion cannot be begun at the proper time without interfering with the healing process. Its alleged **advantages** are—(1) The bones are more readily exposed. (2) It admits of better drainage, through the inner incision.

3. Another method of operating is by **two lateral incisions.** The inner should be made first, and is shorter than the outer, which may be made of any convenient length. The external lateral ligament is divided and the head of the radius removed; and then the humerus is to be disarticulated and forced out at the external wound, and divided by a narrow-bladed saw; next the ulna is cleared, protruded, and sawn. The **advantages** claimed are—(1) Less injury to triceps; (2) it provides better drainage; (3) the scars are lateral and not posterior. In the case of **partial excision** of the elbow joint, where the lower end of the humerus alone is removed, it is necessary to do it through lateral incisions, as it is impossible to reach the joint from behind, on account of the olecranon process. It may be done through a single external lateral incision, but it is usually necessary to use both an external and an internal. Excision of the elbow is a less fatal operation than amputation of the arm. An occasional cause of death is suppurative inflammation of the medullary cavity of the humerus, causing osteo phlebitis, pyaemia, and death.

THE WRIST.

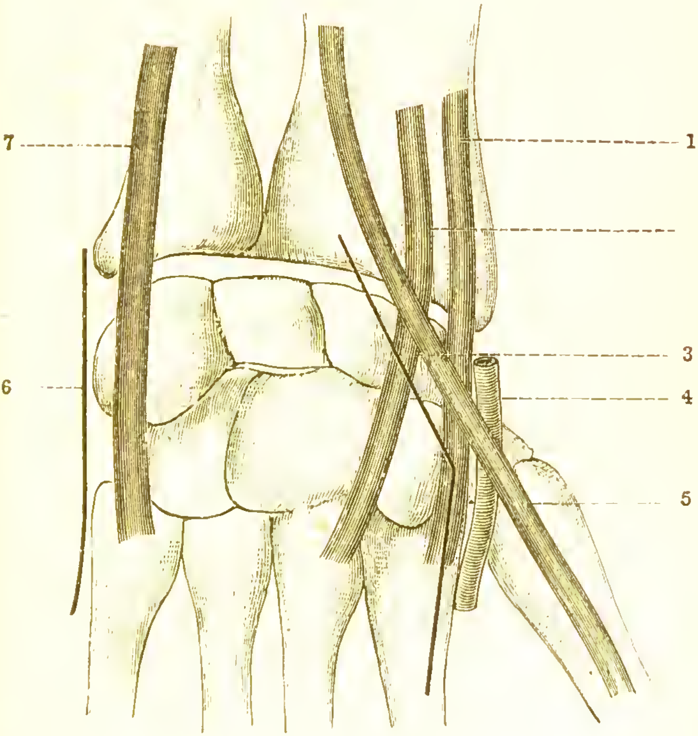
Complete excision of the wrist includes removal of the ends of the radius and ulna, all the carpal bones, and the bases of the metacarpal bones as well (Fig. 22). It may be **required for**—(1) *Injury*, just as in other joints, compound and comminuted fracture, compound dislocation, and gun shot wound; few cases of excision for injury are on record. In the Crimea three cases of wrist injury were excised with one death. (2) *Disease*, as scrofulous caries, excited by some slight injury as a sprain; chronic rheumatic synovitis leading to caries and destruction of the joints.

Principles.—In former times the results of excision were anything but satisfactory, the usual result being either a recurrence of the disease, in cases of partial excision for carious disease, or a stiff and useless hand, from extensive interference with the tendons encircling the joint and imperfect after treatment. Of later years, however, it has been shown that complete excision may be performed and yet leave a useful hand, provided that—(1) all the diseased bones and cartilage-covered surfaces of the radius and ulna, and the bases of the metacarpal bones are removed; (2) that all the tendons concerned in the movements of the fingers and thumb are preserved uninjured; (3) that we can obtain firm fibrous ankylosis of the wrist; but even with firm bony ankylosis the result is good, because the movements of flexion and extension at the elbow make up for the loss of movement at the wrist; (4) that we commence passive movement of *all* the joints of the fingers and thumb very soon after the operation.

1. **Lister's method.**—The **guides** for this operation

are (1) the tubercle on the middle of the dorsal surface of the radius, immediately to the ulnar side of which lies the tendon of the extensor secundi internodii pollicis; (2) the tendon of the extensor secundi, passing

Fig. 21.



LISTER'S EXCISION.

1. Extensor carpi radialis longior. 2. Extensor carpi radialis brevior. 3. The radial incision. 4. The radial artery. 5. Extensor secundi internodii pollicis. 6. Extensor carpi ulnaris. 7. The ulnar incision.

from this tubercle obliquely to the root of the thumb, crossing the radial artery at a point nearly on a level with the base of the metacarpal bone of the thumb.

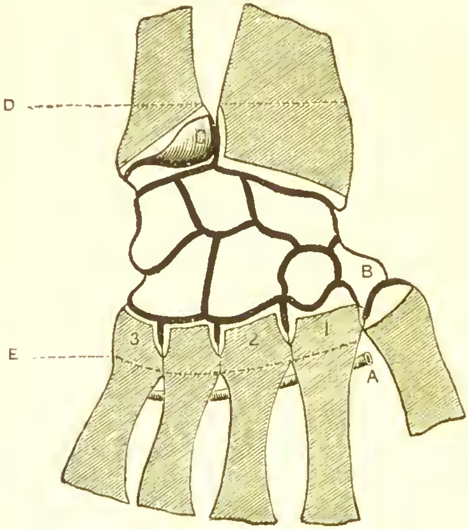
To control hæmorrhage and prevent oozing during the operation, the limb is first emptied of blood by vertical elevation, and Esmarch's elastic tourniquet applied about the middle of the forearm. Any adhesions must be broken down, before beginning the operation, by forcible free movement of all the joints, when the patient is under chloroform. An assistant holds the forearm and hand pronated, with the wrist slightly flexed, and the Surgeon makes the radial incision, starting from the middle of the dorsal aspect of the radius, on a level with the styloid process, and passing downwards and outwards towards the inner side of the metacarpo-phalangeal articulation of the thumb; but, on reaching the line of the radial border of the metacarpal bone of the index finger, it is carried downwards longitudinally for half the length of that bone. The first part of this incision should be parallel with, and a little to the ulnar side of, the tendon of the extensor secundi internodii pollicis, which must not be injured: neither should it be carried too far downwards, lest the radial artery be divided or wounded (Fig. 21). By this incision the tendon of the extensor carpi radialis brevior (2) is divided. The soft parts are then to be separated from the bones, with the knife guarded by the thumb nail, on the radial side of the incision, and in so doing the tendon of the extensor carpi radialis longior (1) is divided close to its insertion, into the base of the second metacarpal bone. The two cut tendons, the undivided extensor secundi, and the radial artery are pushed out of the way, and the trapezium separated from the rest of the carpus by means of the bone forceps, cutting in a line parallel with the longitudinal part of the incision, as in this way there is less risk of

wounding the radial artery. For the present, the trapezium is left in the wound, as its close relation to the radial artery, and the tendon of the flexor carpi radialis, which lies in the groove on its anterior surface, makes its removal at this stage of the operation a difficult matter. The hand is now to be dorsi-flexed, and the soft parts on the ulnar side of the incision dissected up as far as can be conveniently done. A free **ulnar incision** (7) is next to be made, commencing two inches above the lower end of the ulna, and immediately to its palmar surface, and carried downwards between the flexor carpi ulnaris and the ulna, as far as the middle of the palmar aspect of the fifth metacarpal bone. Through this incision the rest of the tendons on the dorsal surface are raised. During all these manipulations the tendons should be raised as little as possible from their grooves on the dorsal surface of the bones of the forearm, or the metacarpus; this is more easily managed if the joint be kept fully dorsiflexed.

The tendon of the extensor carpi ulnaris (6) is next cut as near its insertion as possible, and then the dorsal and lateral ligaments of the joint divided. In raising the soft parts from the palmar surface, through the ulnar incision, the wrist joint should be fully flexed and the knife must be carried close to the ulna, so as to avoid wounding the ulnar artery and nerve. The pisiform bone is to be separated from the other bones, but left attached to the tendon of the flexor carpi ulnaris; the flexor tendons are now raised from the front, till the knife is arrested by the hook of the unciform, which must then be snipped off with the bone forceps. The separation must not extend lower down than the bases of the metacarpal bones, lest the deep palmar arch be

wounded (Fig. 22, A.). The anterior ligament of the wrist is now divided, and the bone forceps applied, so as to separate the carpus from the end of the radius, and then from the metacarpal bones; the separated bones are then removed by the aid of the lion forceps.

Fig. 22.



LISTER'S EXCISION.

A. Deep palmar arch. B. Trapezium. C. Articular surface of the ulna. The dotted lines D. and E. include the amount removed in extensive disease of the wrist; the unshaded parts the amount to be removed in cases where the disease is confined to the carpus. 1, 2, and 3 indicate the metacarpal bones into which the three tendons divided during this operation, are inserted, viz.—1, The extensor carpi radialis longior; 2, the extensor carpi radialis brevior; 3, the extensor carpi ulnaris (after LISTER).

The hand is now everted, and the ends of the radius and ulna are projected through the ulnar incision, and, if extensively diseased, should be sawn transversely wide of the articular surfaces (D.); if only slightly diseased the articular cartilages are alone removed. The ulna is

divided obliquely with a small saw, so as to remove all the cartilage-covered surface, while the base of the styloid process is retained, and in this way the ulna is left but little shortened; a thin slice is then removed from the inferior articular surface of the radius, and the articular facet for the ulna is then denuded by the bone forceps applied almost longitudinally, without disturbing the tendons on the dorsal surface (Fig. 22). Now, protrude the second and the third metacarpal bones from the radial incision, and remove all the cartilage-covered surface with a narrow bladed saw, but saving as much of the length of the bones as can be safely done; the fourth and fifth are next protruded from the ulnar incision and treated in the same way. The trapezium is then seized with the lion forceps and carefully dissected out, and, in doing so, take care of the radial artery, which lies on its outer side, and the tendon of the flexor carpi radialis in the groove on its palmar surface; the head of the metacarpal bone of the thumb is then protruded and cut off with the forceps or saw. Lastly, the pisiform bone is examined; if healthy, the cartilaginous surface is removed and the rest of the bone left, but if diseased it should be entirely removed. The hook of the unciform bone is treated in the same way. The tendons, therefore, divided in this operation, are the three extensors of the wrist. If the bases of the metacarpal bones be divided too low down, the tendon of the flexor carpi radialis may be injured, but it usually escapes, while the flexor carpi ulnaris is left attached to the pisiform bone. All the tendons necessarily divided are cut as long as possible, so that they may form new attachments in the most advantageous position. The radial wound is to be closely united with sutures; the

ulnar incision is closed at each end, but its middle part is left open for drainage, and into this a drainage tube is inserted.

After Treatment.—The hand is placed on an anterior wooden splint, with an obtuse-angled piece of cork, connected to its palmar surface by means of fused gutta-percha, and a transverse bar of cork on the under surface, so as to project from the inner side of the splint. By this means the hand is kept in a state of semi-flexion, and the wrist slightly extended, and this favours union of the severed extensors in the most favourable position. The thumb rests on the upper grooved surface of the transverse bar of cork. The arm is bandaged to the splint, but the thumb and fingers are left free. The great objects are—(1) to procure firm fibrous ankylosis of the wrist, by keeping it in a fixed position for six or seven weeks; (2) to secure perfectly movable fingers and thumb. Passive motion of *all* the joints of the fingers and thumb, including the metacarpo-phalangeal articulations, is commenced on the second day, while the wrist and forearm are kept undisturbed on the splint. The anterior part of the splint may be gradually removed as the range of passive movement is increased. When the patient leaves his bed the arm must be carried in a sling, midway between pronation and supination, and, to prevent the hand drooping to the ulnar side, two ledges of gutta-percha are fixed to the ulnar side of the splint—one to support the hand, the other to keep the splint in proper position.

2. The wrist may also be excised by a **single longitudinal incision** in the central line of the forearm behind, four inches long, commencing one inch and a

half above the styloid process of the radius, and ending one inch below the carpo-metacarpal joints.

The same principles are adopted as in the previous method, and it is therefore unnecessary to go over the operation in detail. An evident disadvantage of the single incision is the absence of sufficient provision for drainage; and, therefore, should this method be adopted, it is advisable to make an aperture for this purpose through the palmar surfaee of the arm, and stitch up the long dorsal incision entirely.

Total excision of the wrist, as above described, is seldom advisable. A rigid anterior splint, with or without elastic extension of the wrist joint, to keep the diseased surfaees at rest and apart, counter irritation, and, if deemed necessary, the hypodermic injection of iodoform or carbolic acid; combined with good food and open air exercise may check the disease and preserve a useful, though crippled hand. The arm must be carried in a sling, midway between pronation and supination, and, most important of all, care taken to preserve the movements of the fingers and thumb, while the wrist joint is kept rigid; in short, it should be treated with the same care as that bestowed on the wrist after excision. It may also be necessary to make incisions to let out pus, and remove disintegrated bone, and scrape away the infiltrated tissues.

CHAPTER XX.

SPECIAL EXCISIONS

(Continued).

THE HIP.

The term 'excision of the hip,' as ordinarily understood, means removal of the head of the femur only, although the acetabulum may also be removed, if thought necessary. **Cases requiring** this operation may be classified as usual—(1) For *disease*, advanced strumous disease, accompanied by abscesses, where the patient is in danger of perishing from exhaustion, and the disease has passed beyond the hope of cure by natural means; the usual means, such as complete rest, extension, incisions to evacutate pus and sequestra, scraping, &c., having been patiently tried and failed. In some cases abscesses do not form (the 'arthritic' form of the disease,) the disease in this case, it is said, having its origin in the synovial membrane, the patient recovering with a useful, though stiffened joint. Just as in the shoulder, the head of the femur is more frequently attacked than the acetabulum, and the upper epiphysis may often be found lying in a state of caries on the dorsum ilii, or in a suppurating cavity with sinuses leading down to it, but the pelvic bones not affected. In these cases excision is indicated to save from a

lingering death from 'hectic' or tedious years of suffering, and secure a more useful limb than nature will, unaided, provide; and the slight operation required for this purpose does not place the patient in any worse position, to say the least of it, than he was in before, and not only so, but removes the cause of the 'hectic'—a chronic form of blood poisoning. Even should there be no sinuses leading down to the joint, if it contain pus, the sooner it is evacuated and the cavity drained, the better—provided it is done antiseptically—for there can be no hope of 'absorption' taking place, matters simply going from bad to worse. At the same time all loose pieces of bone should be removed, the diseased surfaces scraped with a sharp spoon, and the limb then put up in the best position for ankylosis, either by the long splint, or weight and pulley; after ankylosis, the increased mobility of the lumbar vertebræ make up for the stiff hip joint. In the, fortunately, less common form where the disease begins in the acetabulum, the natural termination of such cases is death; in them, therefore, the Surgeon is bound to interfere and excise the joint to provide sufficient drainage for the pelvic abscesses and the removal of loose pieces of bone. Excision for disease in *adult* life is almost uniformly fatal, and the operation is therefore confined to childhood and youth. (2) For *injury*—compound fracture of upper part of femur, the rare condition of compound dislocation and gun-shot injuries. (3) For the *result of disease or injury*, the hip joint ought never to be excised for osseous ankylosis in a bad position. The proper treatment of such cases is (1) to perform subcutaneous section of the neck of the femur as practiced by W. ADAMS; or (2) GANT's operation of subcutaneous section of the shaft

below *both* trochanters, an operation that may be performed in many cases where Adam's operation is impracticable; or (3) SAYRE'S operation of division *above* the lesser trochanter, with concave section of the upper, and convex of the lower part of the divided bone, so as to form a kind of artificial joint. In all cases the limb is then brought down to the straight position.

For the control of **hæmorrhage** apply the elastic tourniquet, as in amputation at the hip joint. It may be excised—(1) by a semilunar incision with its concavity directed forwards, commencing midway between the great trochanter and the crest of the ilium, along the posterior aspect of the great trochanter, or (2) by a longitudinal incision, and then a cross one a little above the great trochanter—T-shaped incision, running somewhat behind the great trochanter with either a transverse incision across its upper end, making it T-shaped, or simply a hook-shaped curve, with the concavity forwards, upwards, and forwards towards the head of the bone; or (3) a simple straight longitudinal incision, four or five inches long, along the posterior border of the great trochanter. In all cases of excision for disease it will be most convenient to begin with a straight incision, it may be through existing sinuses: the joint can then be examined thoroughly, and, if found too far gone for excision, it can readily be transformed into Jordan's amputation.

EXCISION FOR DISEASE.

The patient is placed on the sound side, and then a longitudinal incision is made directly over or somewhat behind the great trochanter; if more convenient the T-shaped incision may be used. The assistant

now adducts the limb and rotates it inwards, and at the same time pushes it upwards till the upper end of the bone is exposed and divided, at a level determined by the extent and situation of the disease, *e.g.*, if the disease has begun in the head of the femur, that bone is sawn below both trochanters, whereas, if it has begun in the acetabulum it may be divided through the neck, leaving the trochanters. Carious cavities must be gouged out of the upper end of the section should any exist, and the acetabulum examined and treated in the same way. It is better to save the periosteum if the case admits of such a thing; this is done by a ⊥ incision, the longitudinal part being over the great trochanter, and the transverse round the bone below the great trochanter; the two halves are then turned aside, with the muscles attached, by a strong periosteum elevator. In this way the periosteum is not stripped off the upper part of the shaft to an indefinite extent, which is otherwise apt to occur.

EXCISION FOR INJURY.

Excision for injury, or in the dead subject, is a much more difficult operation, especially in cases where the neck of the bone is fractured and the leverage of the shaft cannot be utilised to turn the head of the bone out of the acetabulum. The patient is placed on the sound side, and an assistant holds the thigh first slightly flexed, while the operator is making the first incision. Either the semi-lunar or the simple straight incision may be used. The incision must be carried right down to the bone, so as to clear the posterior aspect of the great trochanter, passing through the skin, superficial fascia, with its vessels and nerves, the deep

fascia, and dividing the three glutei muscles, pyriformis, obturator internus and gemelli, obturator externus, quadratus femoris, and part of adductor magnus. The assistant now everts the foot, while the Surgeon divides the remaining structures on the outer side of the great trochanter, as well as the muscles attached to its anterior aspect, chiefly the gluteus medius and minimus, and part of the vastus externus and crureus. The foot is now inverted, and the operator divides the posterior part of the capsule of the joint and the cotyloid ligament, while the assistant again flexes the thigh, forcibly adducts and rotates it inwards, placing his hand against the upper and inner part of the thigh, and pushes it upwards, so as to dislodge the head of the bone, and allow the Surgeon to divide the ligamentum teres and rest of the capsule. In cases where the neck of the bone is broken, the fractured part must be seized with a lion forceps and dissected out. When the head is dislodged, it is grasped with the lion forceps and the bone divided immediately below the great, but above the lesser, trochanter. All bleeding vessels must now be secured; and the vessels most likely to be divided are those in the neighbourhood of the upper part of the great trochanter—viz., branches from the deep division of the gluteal artery; branches of the sciatic artery, and the ascending branches of the external circumflex branch of the profunda; and probably also branches of the obturator, and the internal circumflex branch of the profunda—all of which arteries give nutrient branches to the hip joint.

After Treatment.—An interrupted long splint, with iron brackets opposite the wound, to allow of easy

dressing, may be required, to prevent the femur protruding at the wound. The usual treatment, however, is by the weight and pulley, the foot of the bed being raised, and part of the patient's own weight acting as the counter-extending force. When the wound is partly healed Thomas's hip splint may be applied, and the patient allowed to go about in the open air as much as possible. Bony ankylosis is rare (HOLMES). The shortening is usually pretty considerable, and a high-heeled boot will be required as well as a staff, and probably a crutch.

THE KNEE.

As excision of the knee stands, as it were, on the border-land between amputation and excision, it is necessary that great care be exercised in the selection of cases; in properly selected cases the operation is strikingly successful, but in badly selected cases it is as strikingly unsuccessful. The history of the operation shows a higher death rate than amputation. Cases requiring excision may be—(1) from *disease*, as strumous arthritis with destruction of the cartilages and limited disease of the bone. (2) For *injury*, as lacerated wounds of the joint, compound fracture, compound dislocation and gun-shot injuries. (3) For *results of disease or injury*, as ankylosis in a faulty or useless position. Speaking generally, in a proper case for excision the following conditions are necessary—(1) The disease should be *limited*, not involving the epiphysial cartilages; (2) the patient should be *constitutionally healthy*, there should be no evidence of such a constitutional affection as the tubercular, or waxy disease of internal organs; (3) the conditions requiring

should be the result of an *accident* and not the expression of constitutional mischief, in which case excision would do no good; (4) it must be in the *chronic* stage; (5) there should be no sinuses leading down to suppurating and septic cavities; if such exist, then the operation of excision should only be used as an exploratory measure, with everything ready for amputation there and then if necessary. What amputation to perform will necessarily depend on the state of the case; the four more likely, in order of trial, are CARDEN or GRITTI at the knee, SPENCE or TEAL at the lower third of the thigh. (6) The patient should not be *too young*, as the epiphysial lines are near, and, if injured or removed, the growth of the limb will, to a great extent, be checked; fourteen or fifteen is considered the most favourable age, but it may range from fifteen to thirty years of age. Mr Gant, it is true, has operated successfully on cases at the advanced age of fifty-three, but such examples are rare. Besides, in young children there is a probability of recovery without such a severe operation; rest, incision, scraping, and drainage may work wonders. Further, in children the joint disease is probably only a symptom of profound consitutional cachexia. (7) The patient should not be *too old*, for then the reparative power will be deficient to unite the bony surfaces and fill up the large cavity; beyond 30, as a rule, it is better to amputate; (8) The patient should be in the prime of life, and free from all visceral disease, and able to bear the long confinement to one position, necessary to procure firm, bony ankylosis.

Three forms of **incision** may be used in excision of this joint—(1) The **H**-shaped—a longitudinal incision, at the outer and inner sides of the joint, united by a

transverse one across the patella; this incision necessitates an unnecessary amount of division of textures; (2) a single longitudinal incision in the axis of the limb, from three inches above the patella to below the ligamentum patellæ; this form of incision has no advantage here, as in the elbow joint, and, besides, it gives no opportunity for proper drainage; (3) a horse shoe-shaped incision with its convexity downwards and extending from the posterior margin of one condyle of the femur to the posterior margin of the other, and passing immediately above the tubercle of the tibia. To check **hæmorrhage**, and render the operation 'bloodless,' an elastic tourniquet must be applied to the femoral artery.

By the **horse shoe-shaped incision**.—This is the best form of incision, as there is not the same objection to cross incisions, in excision of the knee joint, as there is in excision of the elbow joint; the object aimed at in the former (the knee joint) is not a movable articulation, and, consequently, a cross incision is an advantage, as the cicatrix tends to contract and keep the parts tight in front.

Position of the patient.—He should be in the recumbent position, his knee being slightly bent (probably already so by disease) is firmly held by an **assistant** seated in front of the patient, or facing the operator, so as to present the knee vertically to the Surgeon, his one hand grasping the thigh and the other hand the leg, while the foot rests firmly on the table. If assistants are plentiful, two may be employed instead of one—one to hold the leg, and the other the thigh. The **Surgeon**, standing on the right side of the limb to be excised, (*e.g.*, if it is the

right knee, he stands on the outer side of the limb), makes the horse-shoe incision according to the rules already given; by this incision the integumentary structures, and the ligamentum patellæ are divided, and the patella turned up in the elliptical flap. The knee is now to be forcibly flexed while the Surgeon divides the lateral ligaments, which allows slight separation of the bones, and he next divides the crucial ligaments by cutting *down upon* the head and spine of tibia, so as to avoid any risk of injury to the popliteal vessels. The bones are now held semiflexed, and the femur raised so as to project its condyles, which are then to be cleared for the saw, the bones of the leg being at the same time pulled towards the table. The Surgeon grasps the part to be removed with the lion forceps, while the assistants steady the leg and thigh, and choosing a *broad-bladed* amputating saw divides the femur through the highest point of the articular surface, and at right angles to the shaft, in the antero-posterior direction, but parallel with the articular surfaces in the transverse—'*parallel to the condyles, and perpendicular to the shaft*' (Heath), in order to avoid any tendency either to knock-kneed or bow-legged deformity. The leg is now forcibly flexed by carrying the foot backwards, so as to project the head of the tibia, which is to be cleared for the saw by means of a blunt pointed knife, lest the vessels behind be injured. The femur is then steadied by the assistant in charge, while the tibia is drawn in front of it, and supported vertically while the operator holds its upper part firmly with his left hand and removes a thin slice with the broad-bladed saw. The section of the tibia must be parallel with its articular surface, and at right angles to its long axis,—*i.e.*, at right angles to its shaft

in both directions. In using the broad-bladed saw, the section of both femur and tibia is made from before backwards; but if preferred a Butcher's saw may be used, and the division made from behind forwards, but it is more difficult by this plan to secure a perfectly flat surface. In cases where the condyles of the femur do not retain their normal shape or obliquity, the guide given by ERICHSEN is the following:—'The patient lying flat on his back, the thigh is flexed to a right angle, and adducted till the inner side of the knee corresponds to the middle line of the body; the saw is then to be held parallel to the surface of the table.' There are two objections to sawing the femur through the highest part of the trochlear surface, as is usually recommended—(1) the section will usually be above the broadest part of the condyles, and more especially during the growing period of youth, and (2) in young persons the lower epiphysis will be entirely removed—this epiphysis does not unite with the shaft till twenty years of age. But is it necessary to go so high? It may in some cases where the disease has spread a considerable distance from the articular surface; but, as a rule, in proper cases the section may be made through the broadest part of the condyles, and any remaining cartilage removed from the trochlea by a Butcher's saw, cutting *round* the bone or else by the bone forceps. The operation of clearing the bones must be conducted very carefully, keeping the edge of the knife close to the bone, on account of the proximity of the large popliteal artery and its articular branches, especially in cases of pathological distortion. The *superior internal articular* passes round the femur, above the internal condyle and *under* the tendon of the adductor mag-

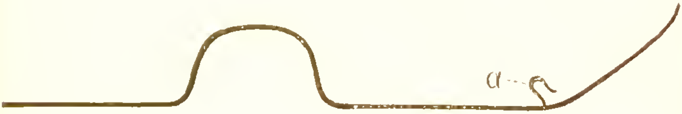
nus, and the *superior external articular* passes round immediately above the outer condyle; the *inferior internal* passes below the internal tuberosity of the tibia, between the bone and the internal lateral ligament of the joint, and the *inferior external* passes above the head of the fibula, but beneath the external lateral ligament and the tendon of the biceps. The *azygos* articular enters the joint by piercing the ligament of WINSLOW.

The *patella*, if much diseased, should be removed; if only slightly it should be denuded as in GRITTI'S amputation; if healthy, it may be left. The arteries likely to be divided in this operation are those taking part in the general anastomoses around, or in the joint, viz.,—The five articular branches of the popliteal already mentioned, together with branches from the anastomotica magna of the femoral, and the recurrent articular branch of the anterior tibial artery. The flap is then turned down and fixed by sutures, and, though no doubt it seems very redundant, it must on no account be curtailed. Drainage tubes are to be inserted into the posterior angles of the incision, hence the necessity of beginning and ending the incision towards the *posterior* part of the two condyles.

After Treatment.—Various forms of splints are used; they usually consist of a padded back splint, reaching from the fold of the nates to near the heel, and a long interrupted external splint, with a foot piece. But the best method is that devised by Dr P. H. WATSON. It consists of two parts:—(1) A suspension rod of iron (Fig. 23), extending from the groin to the foot: the upper part is straight, then there is an arch over the joint, a straight part again for the leg with a hook (*a*) near the

ankle joint, for swinging the limb, and, lastly, a raised part running along the dorsum of the foot. (2) Modelled Gooch splint (Fig. 24), long enough to extend from the tuberosity of the ischium to beyond the heel. It is scooped away opposite the joint, and there is an aperture at the lower end, corresponding to the tendo

Fig. 23.

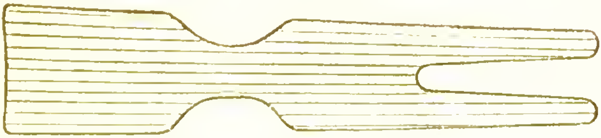


IRON SUSPENSION ROD.

a. Hook for swinging the limb.

Achillis and heel, like a stirrup, the two sides folding up on each side of the malleoli, while the os calcis is in no risk from pressure. The splint is well padded and covered with gutta-percha tissue opposite the wound, and the leg placed upon it. Next, the iron rod is laid on in front, with folded boracic lint between it

Fig. 24.



MODELLED GOOCH SPLINT.

and the limb at the groin, upper part of tibia and ankle. Over all is to be placed abundance of cotton-wool and then *open wove* roller bandages, applied from the toes upwards, and the whole rendered immovable by plaster of Paris applied above and below the knee. The limb is swung from the pulley of a Salter's swing, or from

the top bar of an ordinary cage; the foot and leg being slightly, but not too much, raised. By this means the wound can be readily dressed without disturbing the splint or moving the bones. The limb may be kept in this position for an average period of three months, (it may be more or less), necessary to procure firm union; for other three months it should be encased in a starch bandage, and gradually brought into use for support and progression. When the bones are completely consolidated, a high-heel boot will usually be required, to compensate for any shortening of the limb, usually from one to three inches.

THE ANKLE.

This is an operation but rarely performed; many Surgeons are strongly opposed to it, believing that amputation at the ankle joint is preferable. It may, however, occasionally be performed with advantage: cases appropriate for the operation may be—(1) for *disease*, provided that the disease is strictly limited to the ends of the tibia and fibula, and the articular surface of the astragalus, and that the operation is performed before constitutional exhaustion has supervened. In cases of tubercular disease of the joint, if at all advanced, excision should be viewed with suspicion. The great risk of constitutional infection must not be forgotten—tubercular disease of the testicle, tubercular infection of the lung, and finally, tubercular meningitis carrying off the patient; whereas, in all probability, had the foot been amputated as soon as the disease was discovered, the life might have been saved—it's the old story, 'penny wise, and pound foolish'—saving a *foot* but losing a *life*. 2. For *injury*, as compound fracture

of the malleoli, compound dislocation of the joint, and gun-shot injuries, provided the patient is in the prime of life and unaffected by constitutional disease. In such cases it is often merely a dressing of the ends of the protruded bones, or removal of loose pieces, or disarticulation of the astragalus through the original wound. Various forms of incision are used. (1) HANCOCK'S—An incision beginning behind and about two inches above the external malleolus, carrying it forwards beneath that process, then in front of the ankle joint, and terminating about two inches above and behind the inner malleolus. This incision must not penetrate beyond the deep fascia, so that the tendons and their sheaths are uninjured. (2) The best method is by means of two lateral incisions passing below the two malleoli—one along the inner and posterior margin of the tibia, beginning about two and a half inches above the internal malleolus and passing below it, and then curving forwards round it towards the tendon of the tibialis anticus; the other is of the same extent and form, and is made along the outer margin of the fibula, curving round the external malleolus and forwards towards the tendon of the peroneus tertius. This incision closely resembles BARWELL'S, only he turned forwards at the malleoli at an angle and not in a gently-rounded fashion; it is simply Hancock's without the anterior connection. It is also possible to excise the joint through the EXTERNAL INCISION alone (BUCHANAN), with, should the disarticulation prove difficult, a short straight incision over the internal malleolus, just sufficient to enable the operator to divide the internal lateral ligament. Whatever method be adopted there must be no division of tendons, not even

those that act primarily on the ankle joint proper; because, though the ankle joint be ankylosed, yet the numerous joints in front of this become more mobile and to a great extent make up for it.

By the Two Lateral Incisions.—The limb is emptied of blood by vertical suspension as usual, and the elastic tourniquet applied a little above the knee. The foot is laid on its inner side, and the Surgeon, standing in front of it, makes the external incision according to the rules already laid down; the flap of skin is then dissected upwards, so as to expose the external malleolus and the lower end of the shaft of the fibula. The deep fascia is next to be opened close to the fibula and the peronei tendons (longus and brevis), carefully separated from their groove behind the external malleolus, so that the operator can pass his finger behind that bone: the tendons are then held aside with a blunt hook, and the external lateral ligament divided. The external malleolus is then grasped with the lion forceps, while the bone forceps is used to divide the fibula opposite the upper limit of its articular surface—immediately above the broadest part of the malleolus, after which it is to be twisted out. The foot is now turned on its outer side and the inner incision made, the flap dissected up as before, and the deep fascia divided close to the edge of the tibia; the structures at the inner side of the joint are then to be carefully separated from the bones—tibialis posticus, the long flexor tendons of the toes, and the posterior tibial vessels and nerves. These being held aside, the internal lateral ligament is divided, or the internal malleolus may be treated as the external, being divided with a small saw, and then twisted out. Next, by a forcible wrench, dislocate the

foot outwards, so as to make the astragalus project at the external wound, where its articular surface is removed, or the whole bone excised, according to the extent of the disease or injury. After this the tibia is protruded at the same wound, cleared, and divided. Some Surgeons prefer, the soft parts being held out of the way, to pass a narrow-bladed saw through the wounds, and saw the bone across longitudinally. Branches of the anterior peroneal artery, and perhaps some of the malleolar twigs, will require ligature; the wound should be drained from the external, or from both incisions.

After Treatment.—The method adopted is of little consequence, provided the following conditions are fulfilled:—(1) To keep the foot at *right angles* to the leg; (2) on no account to allow it to become *everted*, a little inversion is of less consequence; (3) it must be maintained in this position during the period necessary to secure firm fibrous or osseous ankylosis—probably not less than three months—of the ends of the tibia and fibula with the astragalus. For this purpose some means must be adopted to dress the wound without disturbing the splint or moving the bony surfaces; some method like that adopted by Watson for knee joint excisions. When the parts are fairly consolidated the leg must be fixed up in some kind of immovable dressing, and gradually brought into use.

CHAPTER XXI.

DISLOCATIONS.

THE UPPER EXTREMITY.

Sterno-Clavicular Articulation.—*Class*, Diarthrosis; *Sub-class*, arthrodia or gliding. The parts entering into its formation are the sternal end of the clavicle, the first piece of the sternum, and the cartilage of the first rib. The articular surface of the clavicle is much larger than that of the sternum, and is invested by a thicker layer of cartilage; the sternal facet is oblique and looks upwards and outwards. Mr MORRIS points out that this obliquity allows the sternum to advance upon the end of the clavicle during inspiration. There is a complete inter-articular fibro-cartilage in this joint: it is a flattened, circular disc, but thinner in the centre than at the circumference, and is attached above to the upper and posterior border of the clavicle, and below to the cartilage of the first rib and lower edge of the sternal facet, and, by its circumference, to the ligaments round the joint. In this way there are two complete joints with two synovial membranes. According to Mr HUMPHREY, these two joints have distinct and separate movements—the one between the clavicle and the disc being chiefly concerned in elevation and depression of the shoulder; while that between the sternum and the disc is concerned in the forward and backward move-

ments, the disc moving with the clavicle. It is this part also that is chiefly concerned in the respiratory movements. As the arm hangs by the side the cavity between the disc and the sternum attains its largest dimensions and is V-shaped; when the arm is raised it becomes slit-like in form, and its cubic capacity lessened, and it is, therefore, this movement that causes most acute pain when the joint is inflamed or otherwise diseased, *e.g.*, in pyæmia. When the joint contains fluid the swelling is best marked on its anterior aspect on account of the thinness of the anterior sterno-clavicular ligament. The most important **ligaments** of the joint are—(1) The anterior sterno-clavicular; (2) The posterior sterno-clavicular; (3) The inter-clavicular, passing from clavicle to clavicle across the episternal notch; (4) The costo-clavicular, or rhomboid, which stretches from the cartilage of the first rib to the rhomboid depression on the under surface of the clavicle. It is a short and very strong ligament, and immediately behind it lies the subclavian vein. (5) The inter-articular fibro-cartilage. **Movements**—(1) To *raise* the clavicle (as in shrugging the shoulders), (*a*) the trapezius, (*b*) levator anguli scapulæ, (*c*) the two rhomboids, (*d*) clavicular head of the sterno-mastoid. (2) To *depress* the clavicle—chiefly gravity, and (*a*) lower fibres of trapezius, (*b*) pectoralis minor, (*c*) subclavius. (3) *Forward movement* (as in pushing), (*a*) chiefly the serratus magnus, also, (*b*) pectoralis major, (*c*) pectoralis minor. (4) *Backward movement*, (*a*) rhomboids, (*b*) middle fibres of trapezius. (5) *Circumduction*, a mixture of all the other movements.

DISLOCATIONS OF THE INNER END.

Dislocation of this bone is rare—(1) Because of the very powerful ligaments of the joint and the thick expanded end of the bone, which gives them a very advantageous attachment. (2) The force is usually transmitted along the long axis of the bone, and it is bent, or broken rather than dislocated. (3) The mobility of the scapula. The strength of the joint is entirely due to ligaments, together with the inter-articular fibro-cartilage; it has no muscular or bony strength. In the order of frequency the dislocations are—(1) **Forwards**—This is usually *caused* by falls or blows on the point of the shoulder, or by bending the shoulder forcibly backwards. The point of the shoulder is *displaced* downwards, forwards, and inwards; the inner end of the bone passes downwards and inwards, and rests in front of the manubrium sterni, and carries its own head of the sterno-mastoid with it. It is readily reduced by simply pulling the shoulders in directions the reverse of the displacements, *i.e.*, upwards, backwards, and outwards. But, as in all joints the strength of which depends on ligaments, the difficulty is to keep it reduced. It should be **treated** in a way similar to that of fracture of the clavicle through its middle—(1) A pad in the axilla, to overcome the inward displacement; (2) a figure of eight round the shoulders to brace them back and so overcome the forward displacement; (3) a sling to support the elbow to overcome the downward displacement. In addition to these measures, however, something must be provided to keep the end of the bone in its place till the torn ligaments reunite. NÉLATON recom-

mends an ordinary hernia truss, the spring passing under the opposite axilla and the pad pressing on the joint; this has to be worn for about two months.

2. **Backwards**—This may be *caused* by the point of the shoulder being driven forcibly upwards, or the hand pulled violently forwards; it may also result from direct violence, such as the kick of a horse. It is, further, sometimes secondary to spinal curvature. The *displacements* resemble the last form, the point of the shoulder being carried inwards. In addition, however, to these signs the dislocated end may press on the trachea, œsophagus, or vessels at the root of the neck, producing difficulty in swallowing or breathing, congestion of the vessels of the head and neck, and probably coma; to relieve these symptoms the end of the bone has been excised. **Treatment.**—A splint well padded, especially opposite the centre of the back, placed transversely behind the shoulders, and to which they are to be braced back by a bandage; in addition to this, should the patient move about, it will be necessary to use an axillary pad and a sling to support the elbow. In all cases of dislocation, the arm must be firmly fastened to the side.

3. **Upwards**—Very rare. It is *caused* by indirect violence such as would carry the shoulder downwards and inwards. The end of the bone passes upwards and inwards behind the sternal head of the sterno-mastoid, which has thus an arched outline; the end of the bone lies between the sterno-mastoid and sterno hyoid muscles in front of the trachea and œsophagus, which are compressed when the patient sits up or leans forwards. The distance between the clavicle and the first rib is increased. The capsular ligament, the sternal

attachment of the inter-articular fibro-cartilage and the rhomboid ligament are all ruptured (SMITH). **Treatment.**—Draw the shoulders outwards and upwards and press the head of the bone into place; then put up as in forward dislocation.

DISLOCATIONS OF THE OUTER END.

Acromio-clavicular articulation.—*Class,* Diarthrosis; *Sub-class,* Arthrodia. **Ligaments**—(1) The superior acromio-clavicular; (2) inferior acromio-clavicular; (3) coraco-clavicular (conoid and trapezoid). *Conoid,* posterior or internal part; broad above and narrow below, passing from the posterior and inner part of the root of the coracoid process, backwards and upwards to the conoid tubercle of clavicle. *Trapezoid,* anterior or external part; passing backwards and upwards from the hinder half of the coracoid process, to an oblique line extending outwards and forwards from the conoid tubercle. (4) An inter-articular fibro-cartilage is sometimes present. **Movements**—At this joint the movements take place round two axes—upward and downward movements of the arm in an antero-posterior axis, and backward and forward movements round a vertical axis, as in throwing the shoulders backwards and forwards—a kind of universal joint by which the scapula and humerus are enabled to maintain the most advantageous relations. The strength of the joint is due to ligaments.

Dislocation of the acromion process of the scapula *(formerly known as dislocation of the acromial end of the clavicle).* Dislocation of this joint is more frequent than dislocation of the sternal end of the clavicle. Two forms are described—(1) The more common is where

the acromion process is forced underneath the outer end of the clavicle (*i.e.*, the end of the clavicle passes on to the upper surface of the acromion process). The *cause* is usually direct violence applied to the scapula, as falls or kicks on the back of the shoulder, not infrequently occurring during the game of football. In complete cases the *diagnosis* is easy; there is pain, loss of power (especially abduction), the shoulder is depressed, and the point an inch or an inch and a half nearer the sternum than on the sound side, but by measurement there is no approximation of the ends of the clavicle. The arm seems lengthened and there is a distinct projection lying on the acromion process. It is often incomplete from the resistance offered to dislocation by the strong coraco-clavicular ligament. **Treatment.**—Raise, draw backward and carry the shoulder outwards, and press the end of the clavicle into position; but, although easily reduced (as the joint is a ligamentously strong one), it is most difficult to keep in position. This is because the articular facet is very small and slanting, the plane of the joint passing downwards and inwards, so that the bones have every facility to slip out again. The method adopted to keep the bones in position will resemble that in dislocation of the inner end of the clavicle. The shoulder is carried upwards, outwards, and backwards, and then a pad of some kind must be placed on the joint to keep the bone in its place, *e.g.*, a Petit's tourniquet, the strap of which is passed under the elbow (bent) of the same side, so as to fix the shoulder and press down the bone at the same time, and held in position by a band passing under the opposite axilla. Fortunately, however, even though the bone is not successfully kept

in proper position, the utility of the arm is but little affected, only a slight limitation in the upward movements.

2. The acromion **forced above the clavicle.**—This form is very rare. The diagnosis and treatment must be conducted on the same principles as the previous form.

3. A third form is said to occur sometimes where not only the acromion process, but the coracoid, as well, is placed above the clavicle.

Dislocation of the Scapula.—The inferior angle sometimes slips from under the latissimus dorsi; this may also take place from paralysis of the serratus magnus muscle, due to injury of the nerve of BELL. When the bone slips from beneath the latissimus it gives a 'winged' appearance to the back. As one of the chief uses of the serratus magnus is for the purpose of pushing, when it is paralysed, the patient can push the sound one more forcibly and further than the paralysed. **Treatment.**—In cases where the angle has slipped from underneath the latissimus a broad belt must be worn to keep the inferior angle close to the chest, otherwise the arm will be much weakened. In paralysis, either of the muscle itself or its nerve, electricity and the endermic or hypodermic application of strychnia.

UPPER END OF HUMERUS.

The Shoulder Joint.—*Class*, Diarthosis; *Sub-Class*, Enarthrosis (ball and socket). This is the most movable joint in the body, and is more frequently dislocated than any other articulation. Its strength is due to muscles, not ligaments, the bones being kept in apposition by the elasticity of the surrounding muscles and atmospheric

pressure. The 'roundness' of the shoulder is caused by the head of the humerus, enveloped by the deltoid muscle; hence when this muscle is atrophied, or the head of the bone is absent from the glenoid cavity, there is 'flattening' of the shoulder. **Synovial Membrane.**—It is very extensive and lines the margin of the glenoid cavity, and is reflected over the internal surface of the capsular ligament, covers the sides and neck of the humerus, encloses the tendon of the biceps in a tubular prolongation, in such a way as to preserve the integrity of the membrane, and exclude the tendon from the cavity of the joint. It sends (1) a prolongation down the bicipital groove for some distance round the tendon of the biceps; (2) it communicates with a bursa beneath the tendon of the subscapularis; and (3) very often with one beneath the tendon of the infra-spinatus. The large subacromial bursa does not communicate with it. The **nerves** of the joint are the circumflex, subscapular, and suprascapular; its **arteries** are the anterior and posterior circumflex, suprascapular, dorsalis scapulæ, and subscapular. **Ligaments.**—(1) The *capsular*, attached above to the margin of the glenoid cavity beyond the glenoid ligament, and below to the anatomical neck of the humerus. It is very lax; it is weakest and least protected at its inferior part. (2) The *coraco-humeral.*—This is a strong bundle of fibres at the upper and anterior aspect of the capsule. It passes from the root of the coracoid process, downwards and outwards to the front of the great tuberosity. A few fibres of this ligament project into the joint and are attached to the upper and inner part of the bicipital groove; this fasciculus is known as the '*gleno-humeral*' ligament, and corresponds to the *ligamentum teres* of

the hip joint. (3) The *glenoid ligament*, a triangular-shaped tire of white fibro-cartilage fixed to the edge of the glenoid cavity; it deepens the cavity and is continuous at its upper part with the tendon of the biceps.

Movements.—(1) *Abduction with Elevation*—(*a*) supra-spinatus; (*b*) middle fibres of deltoid. These only raise the arm to a right angle with the trunk, and the trapezius continues the movement by elevating the scapula. (2) *Adduction*—(*a*) gravity; (*b*) long head of triceps; (*c*) Latissimus dorsi; and (*d*) teres major. (3) *Flexion*—(*i.e.*, movement forwards) by (*a*) anterior fibres of deltoid; (*b*) biceps; (*c*) coraco-brachialis. (4) *Extension* by (*a*) posterior fibres of deltoid; (*b*) teres major; (*c*) latissimus dorsi. (5) *Rotation Inwards* by (*a*) subscapularis; (*b*) pectorals; (*c*) latissimus; and (*d*) teres major. (6) *Rotation Outwards* by (*a*) infra-spinatus; (*b*) teres minor. (7) *Circumduction*—In addition to the above seven movements, other two are sometimes described,—viz., *Adduction with Flexion* (as in crossing the arms in front of the chest) by means of (*a*) the pectoralis major; (*b*) the biceps; and (*c*) the coraco-brachialis. *Adduction with Extension* (as in crossing the hands behind the back) by (*a*) the latissimus dorsi; and (*b*) the teres major. The following peculiarities of this joint deserve special notice:—(1) The large head of humerus and the small glenoid cavity, hence the very free movement; (2) the very loose capsule, and hence the easy pendulum-like motion of the limb in walking; (3) insertion of muscles into the capsule, they are elastic and prevent the capsule from being pinched between the articular surfaces in the various movements of the joint. *Above* is the supra-

spinatus: *Posteriorly*, the infra-spinatus and teres minor; in *front*, the subscapularis; and, *below*, the long head of the triceps. All these muscles are intimately connected with the capsule of the joint, and when they and the deltoid are paralysed the head of the bone may be separated some distance from the acromion process. (4) The relation of the biceps tendon: this is to strengthen the joint, and it also gives steadiness and precision in the finer co-ordinated movements of the arm and forearm. When the joint is distended with fluid, as in **acute synovitis**, it becomes slightly extended and rotated inwards, as in this position the cavity can hold most fluid. The joint is evenly rounded, but a painful bilobed swelling can be felt in the course of the long tendon of the biceps, in the depression between the pectoralis major and the deltoid. It (the joint) is firmly fixed by the muscles in the position of greatest comfort, and movement in any direction, but especially that of flexion and extension, as the biceps is called into play, will give rise to acute pain. This serves to distinguish this condition from another very common one in this region, viz.,—injury to, from a wrench or twist of the arm, or disease of the large subacromial bursa; in this case, flexion and extension do not give rise to any great pain, whereas abduction, by squeezing the bursa, causes acute pain.

Dislocations.—Dislocation of this joint is chiefly met with in middle and advanced life. The strength of the joint is due to muscles, and it is therefore very liable to dislocation. It *occurs* when the arm is abducted and the muscles caught off their guard, or overpowered, as in falls or blows on the shoulder, elbow, or hand, with the arm outstretched; also if the

hand is fixed in this position, and a blow struck on the upper part of the humerus. It is further said to be sometimes due to forcible abduction, or violent contraction of the muscles as in lifting a heavy weight. Whatever the cause may be, the bone always escapes from the capsule at the *lower and inner part*, as in the position of abduction the head presses on this part, which is the thinnest and least supported part of the whole capsular ligament. It does not go straight downwards on account of the long head of the triceps, but passes to the front of that muscle. All dislocations, therefore, of the shoulder are primarily subglenoid. The position which the head of the bone ultimately assumes depends on various circumstances—(1) The direction and amount of the force causing the dislocation; (2) the narrow axillary border of the scapula, so that the bone lies on a sort of knife edge and is readily displaced to one or other side; (3) the relative strength of the muscles on the front and back of the joint, and especially the presence of the long head of the triceps directing it, in the first instance, forwards: the muscles, too, behind are much stronger than those in front, and therefore the forward dislocations are far more common than the backward.

The different dislocations are named according to the position of the head of the bone, in relation to the different bony points around the joint; they will be given here in the order of frequency. 1. **The Subcoracoid.**—This is generally admitted to be the most common form, although the subglenoid, for reasons already given, runs it very close; indeed, some writers give the subglenoid as the most frequent form. Two forms of subcoracoid are sometimes recognised—

(*a*) Subcoracoid proper in which the arm is rotated outwards, and the greater part of the head of the bone is beneath the coracoid process: (*b*) intra-coracoid where the arm is rotated inwards, so that the greater part of the head is placed internal to a line falling from the tip of the coracoid process. 2. Subglenoid; (3) subclavicular; (4) subspinous. In all forms we have—(1) Flattening and squareness of the shoulder; (2) a hollow under the acromion where the head of the bone should be: (3) apparent projection of the acromion process; (4) head of the bone is in an abnormal position; (5) rigidity; (6) pain; (7) alteration in the axis of the humerus, the elbow being flexed, and the forearm supinated. (8) Another symptom, pointed out by Dr DUGAS, is that the patient cannot place the fingers of the injured limb on the sound shoulder, nor allow them to be placed there by the Surgeon, while at the same time the elbow touches the side. The truth of this 'pathognomonic tip,' I am somewhat inclined to doubt, in reference, at any rate, to subcoracoid occurring in young, loose jointed. persons with slightly stooping shoulders. When the hand is on the opposite shoulder the humerus does not lie *transversely* to the chest wall. but very *obliquely*, and there is no reason why, when the spasm of the muscles has passed off, in the form mentioned (the common form), the fingers should not lie on the opposite shoulder. and yet the elbow touch the side. I believe these special 'tips' do a great deal of harm to the student of clinical surgery, and may also lead him into grave errors in practice: the 'tips' are only of value to the experienced Surgeon, who does not require such aids. (9) The vertical measurement of the shoulder. from the axilla round the

acromion process, is said to be one or two inches greater on the dislocated side.

1. **Subcoracoid.**—This is the most common form. The head of the bone is displaced forwards and slightly downwards and rests against the anterior surface of the neck of the scapula, its anatomical neck lying on the anterior lip of the glenoid cavity. *Symptoms.*—(*a*) The head of the bone is felt in the upper and anterior part of the axilla, and partially or entirely obliterates the sub-clavicular fossa; (*b*) there is slight shortening of arm; (*c*) the elbow is tilted outwards, and the axis of humerus is more oblique than natural; (*d*) the head of the bone may press on the axillary nerves; (*e*) inability to move the arm at the shoulder joint; (*f*) measurement of the vertical circumference of the shoulder increased from one to two inches; (*g*) it is impossible to pass a finger into the interval between the coracoid process and the head of the humerus. The latissimus dorsi and teres major draw it towards the chest, while the deltoid and pectoralis major draw it up towards the clavicle. The sub-scapularis muscle is raised from the neck of the scapula and stretched over the head of the humerus. The posterior muscles are drawn tightly over the glenoid cavity and may be partly ruptured.

2. **Subglenoid.**—This is the second most common form (according to some, *the* most common form). *Symptoms*—(*a*) The arm is lengthened about one inch, and tilted outwards; (*b*) there is severe pain and numbness in the hand and arm from pressure of the head of the bone on the axillary nerves and vessels, and by raising the elbow the head of the bone may be readily seen in its new position. (*c*) The circulation may be completely arrested, or the artery may be

ruptured, and the head of the bone can be felt in the axilla below the glenoid cavity. (*d*) The head of the humerus is one or two finger's breadths below the coracoid process. In this case the head of the bone has remained in its primary position—downwards and slightly inwards, resting against the anterior edge of the axillary border of the scapula, between the long head of the triceps and the subscapularis muscles. It is most frequently *caused* by falls on the hand or elbow. The subscapularis muscle is stretched and partly torn; the supra-spinatus is ruptured and probably also the infra-spinatus. The deltoid muscle is much stretched.

3. **Sub-clavicular.**—This is simply an increased degree of sub-coracoid, and probably due to the greater amount of force brought to bear on the limb. The head of the bone lies on the second and third ribs under the pectorals, below the middle of the clavicle internal to the coracoid process, and the symptoms resemble those of the former dislocation. There may also be œdema and coldness of the limb from the interrupted circulation in the axillary vessels. The muscles and other structures round the joint are much lacerated.

4. **Subspinous.**—In the usual form the bone rests on the posterior surface of the neck of the scapula, the anatomical neck lying on the posterior edge of the glenoid fossa beneath the acromion. It may, however, be displaced much further back and lie beneath the spine of the scapula. The axis of the limb is directed forwards and outwards, and the elbow is raised from the side; the head of the bone can both be felt and seen in its new position. The subscapularis muscle is

torn, and most of the other muscles round the joint are rendered tense, especially the pectoralis major; both the teres major and the latissimus dorsi are relaxed. The circumflex nerve is often bruised or torn; and this may induce secondary degenerative changes resulting in the complete and permanent paralysis of the muscle. Mr HOLMES describes a supra-coracoid dislocation, where the head of the bone forms a distinct projection on the top of the shoulder; it is necessarily always associated with fracture of the acromion or coracoid processes, and is *caused* by some violence forcing the humerus upwards.

In diagnosing dislocations of the shoulder the great point to attend to is the relation of the head of the bone to the acromion and coracoid processes. The coracoid process lies in the groove between the pectoralis major and the deltoid, about one inch below the clavicle, and the same distance from its outer end, or opposite the deepest part of the anterior concavity at the outer end of the clavicle. It is about one finger's breadth to the inner side of the head of the humerus. Passing between the process and the clavicle is the strong coraco-clavicular (conoid and trapezoid) ligament. It is necessary to distinguish dislocation from (*a*) fracture of the anatomical neck of the scapula, and (*b*) atrophy of the deltoid muscle. (1) In *fracture* there will be a history of severe direct violence, the displacement is easily reduced but as readily returns when the support is withdrawn; both injuries may occur together. (2) In *atrophy of the deltoid* there will be apparent flattening, but the globular head will still be felt in its proper relation to the coracoid and acromion processes and the joint is freely movable.

Methods of Reduction.—(1) Direct extension and counter extension, *e.g.*, by pulleys. (2) The unbooted heel in the axilla; this is the usual and best method. The heel is pressed against the axillary border of the scapula to steady and fix it, while the upper part of the foot acts as a fulcrum at the upper end of the humerus. It matters but little the exact direction in which the force is applied, as the mobile scapula readily places itself in the most favourable position. The traction should be applied directly to the lower end of the humerus, otherwise, on account of the angle formed by the bones of the forearm with the humerus, some of the force is necessarily dissipated, besides straining the ligaments of the elbow joint. (3) By the knee in the axilla. The Surgeon stands behind the patient, with his foot on the edge of the chair on which the patient is seated, and tries to catch him and the muscles of his shoulder unawares, during the course of the ordinary examination, and thus jerk the bone suddenly into its place. (4) By drawing the arm vertically upwards, parallel with the side of the patient's head, and at the same time fixing the acromion with his foot or other hand. (5) By manipulation. The difficulty in applying this method successfully to the shoulder joint, is the mobility of the scapula. In the sub-coracoid form, the movements are:—flex the elbow to a right angle, adduct as far as possible, rotate inwards till a distinct sense of resistance is felt, then fix the head of the bone, and bring the arm to the side. Unless the attempt at reduction is made immediately after the dislocation, when the muscles are semi-paralysed from shock, the patient should be placed under the influence of chloroform. After reduction of the dislocation, the usual

directions are that the arm should be firmly fixed, for at least two weeks; put up in a sling for another fortnight, and at the end of a month passive motion employed. This amount of rest is unnecessary and decidedly injurious; it is simply playing into the hands of 'bone-setters.' The shoulder is a muscularly strong joint, and there is no tendency, after reduction, to a redislocation. All that is required is to keep the limb at rest for a few days, till the first inflammatory symptoms have passed off, and after that the sooner it is brought into use the better, especially in young persons; at first it is merely to be allowed to swing about easily in a sling, and then passive and active movements begun; or, if in season, give the young patient a spade and pail, and send him to some sea-bathing town. More harm will result from keeping it too long at rest, than from beginning to move it too soon; a good deal may be safely left to the feelings of the patient.

In reducing **old standing dislocations** the probable condition of the axillary artery must be carefully investigated, *e.g.*, whether it is affected with atheroma or calcification, and, whether it may not be included in the new fibrous formations around the joint.

THE ELBOW.

The Elbow Joint.—*Class,* Diarthrosis; *Sub-Class,* Ginglymus. The *bones* entering into its formation are the trochlear surface of the humerus, articulating with the greater sigmoid cavity of the ulna; the lesser head, or capitellum, with which the cup-shaped upper end of the head of the radius articulates. The **synovial membrane** is extensive; it covers the margins of the articular surface of the humerus, lines the coronoid and

olecranon fossæ, lines the inner surface of the various parts of the capsular ligament, and extends for some distance up the humerus, beneath the tendon of the triceps, and lastly lines the lesser sigmoid cavity and inner surface of the orbicular ligament, and covers the head and neck of the radius. The **arteries** are derived from the various vessels that anastomose around the joint; its **nerves** are derived from the ulnar and musculo-cutaneous. The **ligaments** are—(1) The *anterior*, very thin, passing from the humerus above the coronoid fossa to the anterior surface of the coronoid process, and orbicular ligament. (2) The *posterior*, also very thin, passing from the humerus above the olecranon fossa to the upper surface and anterior edge of the olecranon process. (3) *Internal lateral*, consisting of two parts, (*a*) *anterior part*, from the front of the internal condyle of the humerus to the inner margin of the coronoid process; (*b*) *posterior part*, from the lower and back part of the internal condyle to the inner margin of the olecranon process, and a fibrous band spanning the groove between the olecranon and coronoid processes. (4) *External lateral*, from the external condyle of the humerus to blend below with the orbicular ligament. The lateral ligaments are very powerful.

Movements—(1) *Flexion*—By (*a*) biceps; (*b*) brachialis anticus; (*c*) supinator longus (this muscle is chiefly a *flexor*, but does not act till flexion has been begun by the other muscles); (*d*) pronator radii teres (after pronation is completed, or when it is prevented by other muscles), and indirectly by the flexors of the wrist and fingers. (2) *Extension*—By (*a*) triceps and anconeus; (*b*) supinator brevis, and indirectly by the extensors of the wrist and fingers. The movements of the

joint are limited by ligaments, not by locking of the bones.

Acute Synovitis.—When the joint is *distended with fluid*, the swelling first shows itself in the hollows at the sides of the olecranon process, especially on the outer side, filling them up and rising up under the tendon of the triceps, and surrounding the head of the radius; so that instead of having two hollows and a prominence between, as in the normal condition, we find two lateral swellings separated by a depression which corresponds to the tendon of the triceps and the olecranon process. The joint is held semi-flexed, and the forearm semi-pronated, as in this position the joint is able to contain most fluid, from a general relaxation of all the ligaments. Enlargement of the bursa over the olecranon process *(miners*, or *student's (?) elbow)* is to be distinguished from the swelling caused by synovitis, from the fact that the swelling is over the middle line of the joint, obscuring the olecranon, and not at the sides of that process, as in synovitis. The strength of this joint is mainly due to bones; but this bony strength varies with the position of the joint. In *extension*, for example, the coronoid process loses its grasp to a great extent, and it is easy to produce dislocation backwards in this position; but the olecranon process in the same position is advantageously placed and powerfully opposes forward displacements. On the other hand, in *flexion*, the olecranon process loses its grasp, and it is easy to produce forward displacements; but in this position the coronoid process is most firmly locked and opposes backward dislocation. To put it shortly—in full *flexion* the olecranon process has a feeble hold, but the coronoid process a firm hold; in full *extension* the coronoid has a

feeble grip, but the olecranon process has a firm hold. The joint is very strong transversely, from the great breadth of the bones and their locking with one another; also, it has very powerful lateral ligaments, and is supported besides by large muscular masses. In health, there is absolutely no lateral movement; so that if on examining the joint we discover lateral movement it must either be dislocated or disorganised. But the antero-posterior breadth of the joint is small, and the anterior and posterior ligaments very weak, and it has but little support from muscles, and, therefore, antero-posterior dislocations are more common than lateral. It is also important to notice that the movements of the humerus and ulna take place through an oblique plane, as the axis of the arm and forearm do not correspond. In extension the hand passes a little outwards with the bones of the forearm; whereas, in flexion it tends to approach the middle line of the body so as to enable it to convey various articles easily and gracefully to the mouth.

Injuries of all kinds about the elbow joint (including dislocation) possess a peculiar interest to the practical Surgeon, as they often occur in young children, and are apt to be overlooked till it is too late to remedy the injury, and the child must go through life with a crippled arm, which with some care might have been avoided. Dislocations are specially accidents of childhood and youth; more than one-half the dislocations at the elbow occur in boys between the ages of five and fifteen. In 56 cases, 22 occurred under the age of fourteen years. In reference to the diagnosis of dislocation special attention must be paid to the natural relation (1) of the olecranon process to the

prominent internal condyle of the humerus, and (2) the head of the radius to the external condyle. (1) In health the olecranon process lies nearer the internal than the external condyle, and when the elbow is extended it lies almost in a line with the condyles, but when the joint is semi-flexed the point of the olecranon is much below the level of the internal condyle, so that the three processes in this position form a kind of triangle with the apex at the olecranon process. Further, the natural distance between the olecranon process and the internal condyle is only just sufficient to lodge the ulnar nerve. (2) The head of the radius lies immediately below the internal condyle, and may be felt rotating during the movements of pronation and supination. The more important **structures surrounding** the joint are:—In *front*—(1) Skin, superficial fascia, and cutaneous nerves; (2) the superficial veins; (3) deep fascia and bicipital fascia; (4) tendon of the biceps; (5) brachialis anticus; (6) brachial artery; (7) median nerve; (8) radial and ulnar recurrents. *Behind*—(1) The superficial structures; (2) triceps; (3) anconeus. On the *inner* side—(1) The muscles arising from the internal condyle (flexors and pronators); (2) ulnar nerve; (3) inferior profunda artery. On the *outer* side—(1) The muscles arising from the external condyle (extensors and supinators); (2) the musculo-spiral nerve and its divisions; (3) the superior profunda artery.

DISLOCATION OF BOTH BONES.

1. **Backwards.**—This is by far the most frequent dislocation in this region. It is *caused* by indirect violence, as a fall on the palm of the hand, with the

elbow joint extended (or slightly flexed), as in this position the coronoid process loses its grasp of the trochlea, and the bones are driven directly backwards under the lower end of the humerus; this will take place still more readily if the coronoid process be fractured, as sometimes happens. The *symptoms* are (*a*) the arm is semiflexed and pronated, and the whole arm appears shortened; (*b*) there is a projection behind, and a swelling in front, *below* the crease in the skin caused by the flexion of the joint, due to the end of the humerus covered by the brachialis anticus muscle, and the tendon of the biceps; (*c*) the condyles can be felt in front, and the internal one lies below the olecranon process, and the distance between these bones is greatly increased; (*d*) the arm can neither be fully flexed nor extended; (*e*) there is lateral movement of the joint, but the relation of the head of the radius to the ulna is not altered, being bound to it by the strong orbicular ligament which is not ruptured; (*f*) the distance between the condyles of the humerus and the styloid processes at the wrist joint is diminished, but there is no diminution in the distance between the acromion process of the scapula and the condyles of the humerus. If the deformity is easily reduced, and if crepitus be elicited on flexing the reduced bones, and the deformity readily returns when the support is withdrawn, then there is fracture of the coronoid process, as well as dislocation of the bones. It may be possible, by firm pressure in the anti cubital fossa, to feel the broken process. The anterior and lateral ligaments of the joint are torn; the tendons of the triceps-aeconeus attached to the olecranon process is very prominent and tense behind; the biceps and brachialis anticus are

stretched over the end of the humerus, forming the anterior projection.

Treatment.—1. Sir A. Cooper's method—The patient is seated on a chair, and the Surgeon, resting his foot on the edge of the chair, places his knee on the inner side of the joint, while he grasps the wrist and bends the elbow slowly and forcibly; at the same time he presses the upper part of the radius and ulna with his knee, so as to disengage the coronoid process of the ulna from the humerus. 2. Another method is by extension, counter-extension, and co-aptation:—one assistant holds the upper arm, another pulls slowly and steadily at the wrist, while the Surgeon manipulates the bones into position as soon as the coranoid process is unlocked. The arm is then kept in the bent position and carried in a sling, and the ordinary means adopted, if necessary, for reducing inflammatory action. As the strength of the joint (in the antero-posterior direction at any rate) is due to the locking of the bones, passive movement must be begun *early*. It may be left quiet for three or four days till the first inflammatory symptoms subside, and then gentle passive movement must be begun. At the end of two weeks the patient himself may induce active movements of the joint.

2. **Both Bones Forwards.**—This is a rare dislocation —(1) because the long and strong olecranon process opposes such a displacement, and it can hardly occur without fracture of that process; (2) it is *caused* by direct violence, such as a blow or fall on the elbow, and, for this reason again, the usual result is fracture of the olecranon process and not dislocation. The *symptoms* are—(*a*) elongation of the forearm; (*b*) marked pro-

jection of the condyles of the humerus; (*c*) the presence of the sigmoid notch in front of the arm, the olecranon process resting against the inferior part of the trochlea. The distance from the condyles of the humerus to the styloid process of the radius and ulna is increased; the tendon of the triceps is very tense.

3. **Lateral Dislocations** are also rare and usually incomplete, and the outward is more common than the inward. They are rare—(1) because of the strong lateral ligaments; (2) the great masses of muscles at each side; (3) the locking of the bones; and (4) the great transverse breadth of the joint.

ULNA ALONE.

The only dislocation of this bone is backward, and it is very rare. The head of the radius bears its normal relation to the external condyle; the length of the outer side of the arm is unaltered, but the inner side is shortened. The olecranon process is displaced backward, and its distance from the internal condyle much increased. The **treatment** is the same as for both bones backward.

RADIUS ALONE.

The usual dislocations of the head of this bone are (1) Forwards; (2) Backwards; (3) Outwards. 1. **Forwards.**—This is by far the most common of the three, and is in fact the second most common dislocation occurring at the elbow joint. It is *caused* by indirect violence, as falls on the palm of the pronated hand, with the elbow joint extended; it may also be caused by direct violence to the bone behind. It occurs very often in *young* persons. The same form of violence

applied to the arm of a person in the *prime of life* would probably produce fracture of the lower end of the humerus, dislocation of the shoulder, or fracture of the middle of the clavicle; in an *old* person it ordinarily produces fracture of the lower end of the radius (COLLES's); but in *young* persons the usual result is either a dislocation of the head of the radius forwards, or of both bones backwards, not infrequently, however, it is a fracture of the lower end of the humerus, immediately above the condyles. The *symptoms* are—(*a*) the head of the radius lies in front of the external condyle, and there is a hollow where it ought to be; (*b*) the forearm is fixed in a state of semiflexion, and either pronated or midway between pronation and supination, on account of the relaxation of the biceps; (*c*) flexion of the joint is suddenly checked by the head of the radius coming into contact with the lower end of the humerus—it being impossible to flex the joint beyond an obtuse angle; and this is present whether the dislocation is complete or incomplete; (*d*) any forcible attempts at supination or extension of the arm causes severe pain; (*e*) the whole forearm is twisted, with the outer side somewhat upwards. The orbicular ligament is torn.

The other two dislocations are rare and may be diagnosed by feeling the head of the radius in its new position, and, as in all dislocations of the radius, the outer side of the forearm is shortened, and the movements of the joint restricted. They are often accompanied with fracture of the external condyle.

Treatment.—Extension and counter-extension by assistants, while the Surgeon presses the head of the bone into position. As the strength of this joint is due to *ligaments*, it is necessary to keep it at rest for a

lengthened period to allow the ligaments to re-unite, otherwise the action of the biceps will reproduce the displacement. It should be kept perfectly quiet for four or five weeks. In dislocation forward, the joint must be flexed and a pad applied over the head of the bone, and kept in position by a divergent figure-of-eight bandage, which not only keeps the pad in position, but keeps the elbow joint flexed at the same time. Some Surgeons advise that the arm should be extended and the head of the bone kept in position by a pad and straight anterior splint. If preferred, as in other injuries about the elbow joint, two lateral well-padded angular splints may be used.

The treatment of the other dislocations, not specially mentioned, will readily suggest itself from a study of the two common forms.

THE WRIST.

The Wrist Joint.—*Class*, Diarthrosis; *Sub-Class*, An oblong form of hinge, with two axes of movement—a *long* (as in bending the hand backwards and forwards), and a *short* (as in moving the hand towards the ulnar or radial sides); by some it is called a condyloid articulation. The *bones* entering into its formation are—the under surface of the radius above, and the scaphoid, semi-lunar, and cuneiform bones below; the ulna is shut out from the joint by the triangular fibro-cartilage.

The **Synovial Membrane** sometimes communicates with the membrane at the end of the ulna (*membrana sacciformis*). The **arteries** of the joint are the anterior and posterior carpal, anterior and posterior interosseous, and branches from the deep palmar arch; the **nerves**

come from the ulnar and posterior interosseous. **Ligaments** are four — anterior, posterior, internal, and external lateral. **Movements.** — (1) *Flexors* — (*a*) palmaris longus; (*b*) flexor carpi radialis; (*c*) flexor carpi ulnaris. (2) *Extensors*—(*a*) extensor carpi radialis longior; (*b*) extensor carpi radialis brevior; (*c*) extensor carpi ulnaris. (3) *To bend to ulnar side*—(*a*) flexor carpi ulnaris; (*b*) extensor carpi ulnaris. (4) *To bend to radial side*—(*a*) flexor carpi radialis; (*b*) extensor carpi radialis longior; (*c*) extensors of the thumb. **Relations.**—In *front*—(1) radial artery; (2) flexor longus pollicis; (3) flexor carpi ulnaris; (4) palmaris longus; (5) tendons of flexor sublimis; (6) tendons of flexor profundus; (7) median nerve; (8) ulnar artery and nerve; (9) flexor carpi ulnaris. *Behind*—(1) extensores carpi radialis longior et brevior; (2) extensor secundi internodii pollicis; (3) extensor communis digitorum; (4) extensor indicis; (5) extensor minimi digiti; (6) extensor carpi ulnaris. On the *outer* side—(1) extensor ossis metacarpi pollicis; (2) extensor primi internodii pollicis; (3) radial artery; (4) radial nerve. On the *inner* side merely the integumentary structures. Dislocation of this joint is very rare, as most of the so-called dislocations of the wrist joint have usually been found to be fractures. The guide is to be found in the relation of the base of the metacarpal bone of the thumb to the styloid process of the radius; just as in like injuries about the elbow, the guide is found in the relation of the inner condyle of the humerus to the olecranon process. If the styloid process of the radius and the metacarpal bone of the thumb retain their normal relation, the case cannot be one of dislocation. The styloid process of the radius is more anterior, and

passes further down than the styloid process of the ulna. In effusion into the joint, as in **acute synovitis,** the swelling is best seen on the dorsal aspect of the wrist, showing a general fulness, and some bulging between the tendons. The pain is very acute, and, as the joint is so superficial, there will be heat and redness; it is fixed in a slightly-flexed position, and any attempt at movement causes great pain. When, however, the wrist joint is firmly fixed, the fingers may be moved without causing pain; this shows that the inflamation is not in the sheaths of the tendons *(teno-synovitis).* But if, on the other hand, when the wrist joint is fixed, the movements of the fingers give rise to pain, there is strong reason for believing that the synovial lining of the sheaths of the tendons is inflamed. The wrist joint may be dislocated—1. Backwards. 2. Forwards. The usual *cause* is a fall on the palm, or by the hand being bent forcibly backwards.

1. **Backwards.**—*Symptoms*—(*a*) the presence on the back of the wrist of a prominence with a *convex* upper margin: (*b*) the radius and ulna form a projection on the palmar aspect, but the styloid processes retain their normal relationship: (*c*) the length of the forearm is unaltered, but the distance between the styloid processes and the base of the metacarpus is shortened. 2. **Forwards.**—*Symptoms*—The whole hand is displaced to the palmar aspect, and there is a prominence on the dorsum with a *concave* lower margin, caused by the radius and ulna, the styloid processes of which can be readily felt.

Treatment.—Draw the hand forcibly downwards, and press the projection into its proper place; it usually slips in with a snap. Then keep the arm in a sling,

but be careful that the fingers, thumb, and wrist joint do not stiffen.

Any of the bones composing **the thumb** may be dislocated, but the most frequent form is **dislocation backwards of the first phalanx** from the metacarpal bone, where the base of the first phalanx lies on the dorsal surface of the head of the metacarpal bone. It should be **reduced** either by extending the displaced phalanx, or else by forcibly bending it backwards and pressing the head into position, while the metacarpal bone is flexed as much as possible into the palm to relax the flexor brevis. In many cases, however, great difficulty is experienced in effecting reduction; the cause of this difficulty is not perfectly understood. Some, following HEY, believe that the difficulty is due to the strong lateral ligaments of the joint, which grasp the head of the bone; but the great majority of Surgeons believe that the tendons of the flexor brevis muscle is the great obstacle. It is believed that the narrow neck of the metacarpal bone is grasped between the two tendons of the muscle, like a stud between the sides of a button hole. The **treatment** will obviously depend on the view the Surgeon takes as to the cause—either subcutaneous section of one or both lateral ligaments of the joint, or one or both tendons of the flexor brevis muscle.

CHAPTER XXII.

DISLOCATIONS OF THE LOWER EXTREMITY.

The Hip Joint.—*Class,* Diarthrosis; *Sub-class,* Enarthrosis. The **Synovial membrane,** covers the anatomical neck of the femur, lines the inner surface of the capsule, covers the cotyloid ligament, forms a tubular prolongation around the *ligamentum teres,* and lastly covers the mass of fat *(Haversian gland),* lying at the bottom of the acetabulum. The **bones** entering into its formation are the acetabulum and head of the femur. The *acetabulum* is formed by all the three parts of the os innominatum—the ilium forming a little less than two-fifths, the ischium a little more than two-fifths, the pubic bone the remaining fifth. These three pieces unite through the Y-shaped epiphysis in the acetabulum about puberty. The acetabulum consists of a horse-shoe shaped articular surface, which is deficient opposite the cotyloid notch, and a central non-articular depression continuous with the notch. The strongest and deepest part of the cavity is at its upper and posterior part, the lower and inner part being very shallow and weak. The **arteries** of the joint come from the obturator, sciatic, internal and external circumflex and the gluteal arteries; the nerves are derived from the sacral plexus, great sciatic, obturator and accessory obturator nerves. **Ligaments**—(1) The *cotyloid,* a tire of white fibro-

cartilage, attached to the rim of the acetabulum and transverse ligament; it deepens the cavity, closely embracing the head of the femur. (2) The *transverse* bridges over the notch converting it into a foramen, and is continuous at each end with the *ligamentum teres;* beneath it the nutrient vessels pass into the joint. (3) The *ligamentum teres*, or round ligament, is a Y-shaped structure, passing from the two ends of the cotyloid notch to a depression in the head of the femur. (4) The *capsular.* The capsular ligament is attached above to the margin of the cotyloid cavity and transverse ligament; and below—in *front* to the anterior inter-trochanteric line; *above*, to the inner side and upper edge of the great trochanter; *behind* and *below* to the junction of the middle and outer thirds of the neck of the bone. It consists of circular and longitudinal fibres, and, on the posterior and inferior aspects of the capsule, the fibres are almost all circular, so as not to interfere with the swinging movements of the limb as in walking, and in these situations also the capsule is very thin and very loosely attached. On the anterior aspect of the capsular ligament there is a specially thickened part, known as the *ilio-femoral band* or Y-shaped ligament of Bigelow. It is attached above to the anterior inferior iliac spine, and below the two limbs diverge—one to be attached to the upper end of the inter-trochanteric line, the other to the root of the lesser trochanter. The inner slip specially limits extension, and the outer slip, eversion of the femur. There are also other specially thickened parts of the capsule—(*a*) *Ilio-trochanteric* on the superior aspect, passing from the anterior surface of the root of the great trochanter to the ilium, immediately above the

anterior inferior spine. (*b*) *Ischio-capsular* on the under surface, passing from the ischium below the acetabulum to blend with the capsular ligament. (*c*) The *pubo-femoral* ligament, a specially thickened part in front and below. By flexing the thigh upon the trunk and rotating the femur inwards, the Y-ligament is rendered lax; this is of importance in the reduction of dislocations. The centre of gravity falls *behind* the centre of rotation of the hip joint, and the trunk, therefore, naturally tends to fall backwards, but this is prevented by the *ilio-femoral* band. By this wise provision of nature, muscular effort is not required to maintain the erect attitude, so that energy is economised. There is another part of the capsular ligament that requires special notice, viz., the *cervical reflexion*. This consists of bands of fibres which come off from the inner surface of the capsule, and are reflected upwards on to the neck of the femur. This reflexion is not necessarily ruptured in intra-capsular fracture, and conveys blood across the fractured point, and by this means will tend to a certain extent to aid the union of the broken parts. **Movements at the Hip Joint.**—**Flexors.**—These muscles flex the thigh on the trunk, or the trunk on the femur. *Direct* flexors (*i.e.*, those that pass from the trunk over one joint only)—(1) Psoas, (2) iliacus, (3) pectineus. *Indirect* flexors (*i.e.*, muscles passing over two joints, and only acting secondarily on the hip joint)—(1) Rectus, (2) sartorius. **Extensors.**—*Direct.*—The three glutei muscles. *Indirect.*—The three hamstrings (biceps, semi-tendinosus and semi-membranosus). **Abductors.**—(1) Gluteus medius; (2) gluteus minimus; (3) tensor fasciæ femoris; (4) sartorius. **Adductors.**—(1) The three

adductors; (2) gracilis; (3) pectineus; (4) quadratus femoris; (5) obturator externus. **External Rotators.**—(1) Gluteus maximus; (2) Gluteus medius (posterior part); (3) pyriformis; (4) obturator internus and the two gemelli; (5) quadratus femoris; (6) obturator externus; (7) psoas and iliacus. **Internal Rotators.**—(1) Gluteus minimus; (2) gluteus medius (anterior part); (3) tensor fasciæ femoris. It will be noticed that the external rotators are much more numerous and powerful than the internal, so that the foot naturally tends to fall outwards when one assumes the supine position. **Muscles in direct contact with the Capsule of the Hip Joint.**—In *front*—Psoas and iliacus. *Above*—(1) Rectus (reflected tendon), (2) gluteus minimus. On its *inner* side—(1) Pectineus; (2) obturator externus. *Behind* it—(1) Pyriformis, (2) obturator internus and the two gemelli, (3) part of gluteus minimus, (4) obturator externus, (5) quadratus femoris.

The **range of motion** of the joint in its various directions is **limited,** in a general way, as follows:—*Extension* by the anterior fibres of the capsule and ilio-femoral band; *flexion* by the contact of the neck of the femur with the acetabulum and soft parts of the groin; *abduction* by the pubo-femoral band and lower part of the capsule; *adduction* by the ilio-trochanteric band and upper part of the capsule in extension, and ligamentum teres in the flexed position: *external rotation* by the inner limb of the Y-shaped ligament during extension, and the outer limb and ligamentum teres during flexion; *internal rotation* by the ischio-femoral, or Y ligament. The *ligamentum teres* is rendered tense either when the thigh is partly flexed and adducted, or

when the limb is flexed and rotated outwards,—*i.e.*, flexion with adduction or external rotation.

In effusion into the joint, as in **acute synovitis**, (a rather rare condition, pure and simple), the swelling will be difficult to detect, on account of the depth of the joint from the surface, and the thick capsule. As in other joints, it will tend to show itself where the capsule is thinnest—in *front*, internal to the inner head of the Y-shaped ligament, and *behind* at the posterior and lower part of the capsule. In these parts, therefore, any swelling and tenderness must be first looked for; the joint at the same time will be flexed, abducted, and rotated outwards, as in the position of flexion the joint holds most fluid with the least tension, and abduction and eversion relax the outer and inner bands, respectively, of the ilio-femoral ligament.

DISLOCATIONS OF THE HIP JOINT.

The dislocations of this joint are various, but whatever position the head of the bone ultimately assumes, the primary dislocation, just as in the shoulder joint, is *always* in a downward direction. The forms of regular dislocation in order of frequency are—(1) Backwards and upwards upon the dorsum ilii; (2) backwards into the great sacro-sciatic notch; (3) forwards and downwards into the foramen ovale; (4) forwards and upwards upon the pubes. The first two forms are the most common; in all the four forms the ligamentum teres is usually ruptured, but the ilio-femoral band remains intact.

We have to notice the influence exerted (1) by the Y-ligament; (2) by the tendon of the obturator internus, as it is found in the gluteal region, on the various

forms of regular dislocation of this joint—(1) **The Y-ligament.**—If this ligament escape rupture, we may get any of the four *regular* forms of dislocation enumerated above; if it be wholly ruptured the dislocation will be of an *irregular* form. In no case do muscles (except perhaps the obturator internus) exercise any direct influence on the displacement. In dislocation on to the dorsum ilii, and into the great sacro-sciatic notch there is marked *inversion* of the limb; this is because the ilio-femoral band is not ruptured, and the external rotators are powerless to rupture it, and are therefore unable, so long as the ligament remains intact, to evert the limb. For the same reason, in dislocation into the foramen ovale the limb is *flexed*. In dislocation on to the pubes the ligament is lax, and hence the external rotators are at liberty to act, and, having nothing to oppose them, produce marked *eversion*. (2) **The Tendon of the Obturator Internus.**—BIGELOW has pointed out that the muscular body of this muscle is usually mixed with tendinous structure; by this means it acquires great strength, and when contracted acts as a powerful accessory ligament on the posterior aspect of the hip joint. It has also been pointed out by the same Surgeon that in dislocations on to the dorsum ilii, and into the great sacro-sciatic notch, the bone passes in exactly the same direction in the first instance; but, in dislocation on to the dorsum ilii, the head, in passing upwards and backwards, passes *between* the tendon of the obturator internus and the pelvis, whereas in dislocation into the great sacro-sciatic notch, the head of the bone as it passes backwards, passes *behind* the tendon of the obturator internus, the tendon lying over the neck of the bone and preventing its ascent.

Mr Morris states that when the limb is flexed, abducted, and rotated inwards, the backward dislocations are produced; in *moderate* flexion the head rests on the dorsum ilii, in *extreme* flexion it comes to rest near the sciatic notch. When the limb is abducted, extended, and rotated outwards, the dislocation upon the pubes occurs. In very forcible abduction the head of the bone is sent into the perinæum. If there be neither rotation, forced flexion, nor extension, the head of the bone rests in its primary position — in the thyroid foramen. The dislocations, therefore, it will be observed, all occur in the abducted position of the limb, because (1) during abduction the head of the bone passes to the shallowest and weakest part of the acetabulum; and (2) during abduction the ligamentum teres is loose. The same condition of parts is also brought about, even when the limb is not abducted, if the body be forced over to the dislocated side. The reverse is true in regard to the adducted position. The point at which the head of the bone will ultimately come to rest, depends on the direction and amount of the violence, as well as on the position of the limb. Dislocations occur chiefly in men during the middle period of life (twenty to fifty), and is specially apt to be produced in certain occupations, as miners and navvies. The same application of violence in an *old* person will produce intracapsular fracture of the neck of the bone; in *young* persons fracture of the shaft.

There are **special test lines** made use of in the diagnosis of dislocations of the femur and fracture of the necks of the bone. I. **Nélaton's Test Line.**—Draw a line from the anterior superior spinous process of the ilium over the outer side of the hip to the tuberosity

of the ischium. In health the top of the great trochanter should just touch this line in every position of the joint. 2. **Bryant's Triangle.**—The patient is laid flat on his back, on a firm mattress or couch, and a perpendicular is dropped from the anterior superior spine of the ilium; then a second line at right angles to the first is dropped from it to the top of the great trochanter; then the two lines are joined by a third one from the anterior superior spine to the top of the great trochanter, thus completing the 'triangle.' The length of the *second* line, compared with a corresponding line on the opposite side, shows the amount of vertical displacement; the length of the *third* line shows roughly the degree of displacement of the trochanter backwards or forwards. The advantage of Bryant's method is that the measurements can be taken without moving the patient, which is of importance in cases of fracture 3. **Morris's Bitrochanteric Measurement.**—This is chiefly of use in cases of fracture, and shows the degree of inward displacement of the trochanter, just as Bryant's method shows the degree of vertical displacement. The distance from the tip of the great trochanter to the symphysis pubis is measured on both sides and the figures compared; on the injured side the distance between the two points is always less. Mr MORRIS has constructed a special measuring rod for this purpose, which shows the state of affairs at a glance. To judge of the position of the head of the femur in *dislocations* look to the lie of the internal condyle of the femur, because the direction of the head and that of the internal condyle are almost the same (BIGELOW).

THE BACKWARD DISLOCATIONS.

1. **Upon the Dorsum Ilii.**—In dislocation on to the *dorsum ilii* (backwards and upwards), which is the most common form, the limb is shortened one or two inches, the knee is inverted, slightly flexed and advanced, and rests against the lower third of the opposite *thigh*, and the great toe rests on the tarsus of the opposite foot; the heel is a little raised, and the thigh is flexed, and there is a great bulging at the hip from the projection of the great trochanter, which is directed forwards and lies nearer the anterior superior iliac spine than natural. The head of the bone rests on the ilium, a little above and behind the acetabulum; it is made to lie at this point partly by the force causing the dislocation, but is also pulled up by the glutei, hamstrings, and adductor muscles. Abduction and eversion are impossible, but there is still a slight amount of inversion, adduction, and flexion possible. Another symptom, first noted by SYME, is that if the patient be laid flat on his back on a hard couch or table, the knee of the dislocated side is raised, but the patient's back rests evenly on the table; but if the knee be brought down flat on the table there is a marked lumbar curve produced, just as in hip joint disease. On pressing the fingers into the groin it will be found that the femoral vessels have lost their firm posterior support and seem to lie over a hollow. The short muscles covering the joint behind are much lacerated; the ilio-psoas muscle is very tense, and the pectineus may be torn as well as the glutei. According to BIGELOW the head of the bone passes between the tendon of the obturator internus and the innominate bone, and finally comes to rest above that

tendon (*'backward dislocation above the tendon'*). This dislocation is caused when the limb is in the position already explained (abduction, flexion, and internal rotation), and the patient receives a blow on the back, the result being either a dislocation, or a fracture of the shaft of the femur, as in miners; it may also occur when a person is carrying a heavy weight and falls down.

2. **Into the Sciatic Notch** (*backwards*). — The *symptoms* of this form resemble very closely those of the previous dislocation, only they are less marked—it is simply a less advanced form. The limb is shortened about half an inch, the knee is inverted and touches the opposite knee, but does not tend to cross over it, and the ball of the great toe rests on the head of the metatarsal bone of the great toe of the opposite foot. There is less flexion and less bulging at the hip than in dislocation on to the dorsum ilii. The head of the bone rests, not in the sciatic notch, as the name would imply, but on the back of the ischium, opposite, or a little above, the level of the spine, and below the tendon of the obturator internus muscle (*'backward dislocation below the tendon'*).

The backward dislocations must be **distinguished** from—(1) *fracture of the neck with inversion.* In ordinary cases of fracture there is usually marked eversion, which at once distinguishes it from ordinary forms of dislocation. This form of fracture is rare, and the *increased* mobility and the existence of crepitus will aid the diagnosis. (2) *Impacted extracapsular fracture with inversion.* Here the limb will probably be extended; BRYANT'S line shortened from half to one inch, approximation of the great trochanter to the middle line

as shown by the 'bitrochanteric' measurement. There will be great pain over the trochanter, but the joint will permit movement freely in all directions, though the great trochanter will not move in so large a circle as on the sound side. Further, there will be the usual feeling of resistance in the groin behind the femoral vessels. *Great care is necessary in performing these manipulations, lest the impacted fracture be converted into an unimpacted one.*

Reduction of Backward Dislocations by Manipulation.—The great object is to make the head of the bone pass back to the acetabulum in exactly the same direction as it left that cavity, and, therefore, the limb must be put into the same positions as that in which the dislocation occurred, viz., flexed, abducted, and rotated outwards. The success of the method depends on the integrity of the ilio-femoral band; it is to act as the fulcrum of the lever, of which the shaft of the femur below it is the long arm, while the part above it is the short arm. The manipulations are—(1) **Flex** the leg on the thigh to relax the hamstrings, and the great sciatic nerve, if need be, and also flex the thigh upon the abdomen, carrying it at the same time into a **position of adduction**, so as to relax the untorn part of the capsule. (2) **Circumduct outwards** (a combination of abduction and external rotation) so as to distend the rent in the capsule, make the head pass round the way it came, and turn it through the opening in the capsule. (3) Quickly **extend** and bring the limb to the side of its fellow, so as to make the head pass at once into the deepest part of the acetabulum. When the dislocation is reduced the legs may either be tied together with a pillow between the knees, or the long splint

applied. The splint is to be kept on for a week or ten days, and after this the joint should be supported by some fixed apparatus, as a leather splint or a plaster of Paris spica, for two weeks longer.

THE FORWARD DISLOCATIONS.

3. **Into the Foramen Ovale** *(forwards and downwards).*—The head of the bone rests in the thyroid foramen. **Causes.**—Sudden and violent abduction, unaccompanied either by external rotation, or fixed flexion or extension. Jumping or falling from a height, with the feet widely apart, as sliding over the end of a loaded waggon or cart. The sudden movement of a carriage when one foot is on the step but the other not yet off the ground; also getting out of bed quickly and one foot is caught in the bed-clothes, while the other descends suddenly to the floor. The pectineus, gracilis, and adductors longus and brevis are torn, and the psoas, iliacus, glutei, and pyriformis are put on the stretch; the ligamentum teres and capsule are ruptured as before. The obturator nerve is stretched or torn. *Symptoms.*—The limb seems *lengthened*, the toes point downwards and are a little everted, and the foot is separated some distance from the other one—the thigh being flexed and abducted, and in front of the opposite one, on account of the tension of the ilio-psoas muscle. The hip is flattened, and the prominence of the great trochanter absent. The apparent lengthening is believed to be due to a tilting of the pelvis over to the injured side; to make quite certain whether it is lengthened or not, the use of BRYANT'S test, or careful measurements must be made from the anterior superior iliac spine to some fixed bony point in the limb, *e.g.*, the tip of the

internal malleolus. The movements of adduction and extension are impossible without using great force, and giving rise to severe pain from pressure on the obturator nerve; the limb, however, may still be flexed.

4. **Upon the Pubes** *(forwards and upwards).*—The head of the bone rests on the ilium, rather than the pubic bone, close to its junction with the horizontal ramus of the pubes and on the outer side of the femoral artery. It is **caused** by violence similar to that producing the thyroid variety; but where extension and external rotation of the limb accompany the application of the violence. *Symptoms.*—The limb is shortened and abducted, and there is marked eversion of the foot and knee, and the heel inclines towards the opposite one. The great trochanter lies nearer the middle line than the anterior superior spine. The limb cannot be rotated inwards, but may be slightly flexed. There is sometimes pain and numbness down the thigh from pressure on the anterior crural nerve. This form is said to resemble fracture of the neck of the femur; but it may be distinguished from this by the greater immobility, and by the situation of the head of the bone in the groin.

Reduction of the Anterior Dislocations.—(1) **Flex** the leg upon the thigh and the thigh upon the abdomen, as in the previous dislocations, but at the same time **abducting** the limb. (2) **Circumduct inwards** until the knee is brought nearly to the middle line of the body; these movements relax the capsule, disengage the head of the bone, and bring it round to the opening by which it escaped. (3) **Extend** and rotate outwards, so as to make the head of the bone re-enter the acetabulum.

THE IRREGULAR FORMS.

There are many **irregular** forms of dislocation, but the following are a few of the better marked varieties:—

1. **Everted Dorsal.**—This has all the usual signs of dorsal dislocations except that there is eversion instead of inversion, and there is but slight adduction and the limb may be extended. It is supposed by some that the outer band of the ilio-femoral ligament is ruptured.

2. **Supra-spinous.**—The limb is shortened to the extent of two or three inches, a little abducted and everted, and the head of the femur is felt just below the anterior superior spine of the ilium, above and to the outer side of the ilio-femoral ligament. As in the last form, the outer head of the ilio-femoral ligament is believed to be torn.

3. **Sub-spinous.**—The hip is flattened, Bryant's line is shortened about two inches, there is extensive eversion and the head of the femur is found below the outer part of Poupart's ligament, a little to the inner side of the anterior inferior iliac spine.

4. **In the Perinæum.**—This occurs when the limb is greatly abducted at the moment the violence is applied. There is extreme abduction and marked flexion, and the head of the femur can be felt in the perinæum. The foot may be either inverted or everted.

THE KNEE.

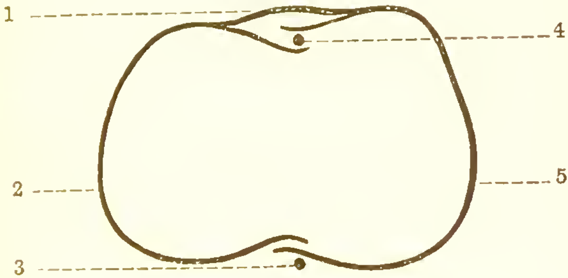
The Knee Joint.—*Class*, Diarthrosis: *Sub-class*, Ginglymus. The **bones** entering into its formation are—(1) The *femur*, with its TROCHLEAR surface which is *highest* and most prominent on the *outer* side; and the articular surfaces of the CONDYLES of which the

inner is the more elongated from before backwards. (2) The *tibia*, with its two surfaces—of which the internal is the longest, narrowest, and deepest, the external being the reverse. (3) The *patella*, with its SEVEN facets. The **synovial membrane** is the largest in the body. It forms a large *cul-de-sac* beneath the extensor muscles of the thigh, extending upwards for an inch at least above the articular surface. At the sides it passes beneath the vasti and ascends higher on the *inner* than on the outer side of the limb beneath these muscles (being the reverse, therefore, of the articular surfaces). This large pouch is supported during the movements of the joint by the sub-crureus muscle which is inserted into its upper part. Above the pouch there is a bursa extending upwards for another inch, and which usually communicates with the cavity of the knee joint. It also covers both surfaces of the semi-lunar cartilages, and on the back part of the external one sends a tubular prolongation round the tendon of the popliteus muscle for some distance. It further surrounds the crucial ligaments by tubular prolongations, lines the whole interior of the capsule, and lastly, very frequently extends into the superior tibio-fibular articulation. The **arteries** are *seven* in number—anastomotica magna, five branches from the popliteal artery, and the recurrent branch of the anterior tibial. The **nerves** are nine in number, branches from the obturator, from the nerve to the vastus externus, from the nerve to the vastus internus (both from the anterior crural), three from the internal popliteal, two from the external popliteal, and the recurrent articular from the termination of the same nerve. The **ligaments** of this joint are very numerous, and are divided into

internal and external sets. External—(1) The internal lateral, a broad flat band from the back part of the inner tuberosity of the femur to the inner tuberosity and upper part of the shaft of the tibia. Beneath it pass the inferior internal articular vessels. (2) The external lateral—*long* part, passing from the back part of the outer tuberosity of the femur to the outer part of the head of the fibula. It pierces the tendon of the biceps and under it pass the tendon of the popliteus and the inferior external articular vessels. The *short* part is more posterior, and is attached below to the apex of the styloid process of the fibula. (3) Posterior ligament, or ligament of Winslow, a broad flat band principally derived from the tendon of the semi-membranosus. (4) Ligamentum patellæ, the continuation of the tendon of the quadriceps extensor cruris, passing from the apex of the patella to the lower part of the tubercle of the tibia; between it and the upper part of the tubercle is a small bursa, and a large mass of fat (the *infra-patellar* pad) separates it from the synovial membrane of the knee joint. (5) The capsular, which is a strong fibrous membrane filling up the gaps left by the other ligaments, and is strengthened by fibres from the various muscles surrounding the joint. Interior ligaments—(1) *Crucial*, anterior, and posterior. (*a*) The *antero-external* is attached below to the inner part of the pit in front of the spine of the tibia; above, to the inner and hinder part of the external condyle of the femur. Its direction is upwards, backwards, and outwards. (*b*) The *postero-internal* is attached below, to the back of the pit, behind the tibial spine; above, to the fore part of the inter-condyloid hollow and side of the inner condyle. Its direction is upwards and a

little forwards. (2) The *semi-lunar cartilages.* (*a*) The *internal* forms almost a semi-circle, and embraces the ends of the external. Its anterior end is attached to an impression towards the front part of the internal articular surface; its posterior end is attached to the inner edge of the hollow behind the spine of the tibia, along with the posterior crucial ligament. (*b*) The *external* forms about three-fourths of a circle, and its anterior and posterior ends are interposed between the attachments of the internal cartilage, in front of, and behind, the spine of the tibia. (3) The transverse

Fig. 25.



HEAD OF LEFT TIBIA.

1. Transverse ligament. 2. External semilunar cartilage. 3. Posterior crucial ligament. 4. Anterior crucial ligament. 5. Internal semilunar cartilage.

ligament, which passes between the two cartilages. (4) The coronary ligament, which connects the convex borders of the cartilages with the head of the tibia. (5) Ligamentum mucosum, which is simply a process of synovial membrane. (6) Ligamenta alaria, its fringed borders. The following structures are found upon the head of the tibia from before backwards (Fig. 25):—(1) Transverse ligament; (2) anterior extremity of internal semi-lunar cartilage; (3) anterior crucial ligament; (4) anterior extremity of external semi-lunar

cartilage; (5) posterior extremity of external semi-lunar cartilage; (6) posterior extremity of internal semi-lunar cartilage; (7) posterior crucial ligament. The key to the position is to remember that the internal cartilage embraces both ends of the external, and that the anterior crucial is placed *between* the two anterior ends, but the posterior is behind both the posterior ends.

The **movements** of this joint are in some respects peculiar. (1) It is not a pure hinge-joint, but has in addition a gliding and rolling movement. In these movements the semi-lunar cartilages (which may be regarded as inter-articular fibro-cartilages) form movable and accurately fitting wedges. (2) The movement is through an oblique plane, the axis of the femur is downwards and inwards, but when the leg is flexed it is parallel with the thigh. (3) There is a movement of rotation at the completion of extension which is called the 'locking' or 'screwing home' of the joint. (4) When the knee is partly flexed, the joint admits of internal and external rotation. Another point worthy of notice is the movements of the patella on the articular surface of the femur. This is a movement partly of gliding and partly of co-aptation. The patella has seven facets on its articular surface—three pairs, and one internal perpendicular facet. When the knee is extended, as in the erect position, the two inferior facets are in contact with the upper part of the trochlear surface of the femur; in semi-flexion, the middle facets come into contact with the femur; in still greater flexion, the superior pair are brought into contact, while in extreme flexion, the patella leaves the trochlear surface of the femur altogether, and the internal perpendicular facet lies in contact with the outer margin of the inner

condyle. Further, at the completion of extension, there is a slight rotation outwards to 'lock' the joint; and, at the beginning of flexion, there is a slight rotation inwards of the leg and foot to 'unlock' it. The centre of gravity of the body, in the erect attitude, falls in *front* of the axis of motion of the knee joint, and there is a tendency, therefore, to over-extension; but this is impossible, because of the tension of the lateral, posterior, and *anterior* crucial ligaments (the *posterior* crucial being tightened in flexion). In this way the erect attitude is maintained without the expenditure of muscular energy. **Flexors.**—*Direct*—(1) Biceps, (2) Semi-tendinosus, (3) Semi-membranosus, (4) Popliteus. *Indirect*—(1) Gastrocnemius, (2) Plantaris, (3) Sartorius, (4) Gracilis. **Extensors.**—Quadriceps extensor cruris (formed by the two vasti, the rectus femoris and the crureus). **External Rotator.**—(When the limb is partly flexed)—The biceps muscle as a whole. **Internal Rotators.**—(1) Popliteus—(this is the chief one, but only acts when the knee joint is flexed, and the tendon of the popliteus lying in its groove), (2) Semi-tendinosus, (3) Semi-membranosus, (4) Sartorius, (5) Gracilis. To **lock home** the joint at the completion of extension.—The extensor muscles as a whole cause a slight rotation outwards. To **unlock** the joint at the commencement of flexion—(1) The sartorius, (2) the gracilis, (3) the semi-tendinosus.

The different movements of the joint are **limited** in something like the following manner—*Flexion* is checked by the contact of the soft parts of the leg and thigh chiefly; but during this movement the posterior crucial ligament and the ligamentum patellæ are also tightened, but all the other ligaments are relaxed

Extension is limited by the lateral, posterior, and anterior crucial ligaments; during this movement the posterior, crucial, and ligamentum patellæ are relaxed, when the limb has been brought into a straight line *over-extension* is mainly checked by the tension of the posterior crucial, and posterior ligaments; forcible over-extension of the joint may rupture the posterior crucial, *e.g.*, when the leg is supported horizontally on a chair and some heavy weight falls forcibly upon the anterior aspect of the knee. *Internal rotation* (in the semi-flexed position of the knee) is checked by the *anterior* crucial ligament; *external rotation* is checked by the posterior crucial. The crucial ligaments are also important agents (probably the chief) in the prevention of lateral movements of the joint; hence in cases where the bones move laterally in the extended position of the limb, there is good reason to believe that the crucial ligaments are destroyed.

In effusion into the joint, as in **acute synovitis**, the swelling first shows itself at the sides of the ligamentum patellæ, because at these points the synovial membrane is least supported and nearest the surface. The swelling gradually extends upwards under the quadriceps extensor to the extent of three or four inches above the upper border of the patella, the swelling being higher on the *inner*, than the outer side of the limb. Fluctuation is readily detected, and the patella is floated up off the surface of the femur, and by firm, sudden pressure it may be made to tap against it. This floating of the patella is a very valuable sign of effusion into the joint, as it may be detected before either fluctuation, or very marked swelling. The position of the limb is one of moderate flexion, combined with external rotation of

the head of the tibia, as in this position the cavity holds most fluid, and it, at the same time, relaxes the more powerful ligaments of the joint (posterior ligament, posterior crucial, and lateral ligaments. Should, however, the joint remain long in this position, there is a tendency for the head of the tibia to be partly dislocated backwards, from the continued action of the hamstrings, conjoined with yielding of the crucial and lateral ligaments. The following muscles act on both hip and knee joints—(1) The biceps; (2) semimembranosus; (3) the semitendinosus; (4) the rectus femoris; (5) the sartorius; (6) the gluteus maximus (through the *ilio-tibial band*); (7) the tensor fasciæ femoris (through the *ilio-tibial band*); (8) the gracilis. It is evident, therefore, that in disease of either the hip or knee joints, both will require to be kept rigid, in order that the diseased one may be at rest.

There are three circumstances which tend to make this joint insecure—(1) The configuration of the articular surfaces of the bones; (2) the fact that it is between the two longest bones in the body, and, therefore, powerful leverage is brought to bear upon it; (3) its great mobility. Nevertheless, dislocation of this joint is rare, its great strength being due to its very powerful ligaments.

DISLOCATION OF THE KNEE JOINT.

This is a rare form of accident for reasons already stated, and, when it does occur, it is usually complicated with such injury to the popliteal vessels as to necessitate amputation. Other complications are also likely to arise from the force required to dislocate it,

such as rupture of ligaments and muscles, and gangrene may result, or the joint may fall into a state of suppurative or destructive inflammation, so that dislocation of the knee joint is more liable to complications than any other joint. Diastasis of the condyloid part of the femur in young children may resemble dislocation of the knee joint. It may be dislocated to either side forwards or backwards.

1. The **lateral** dislocations are most common and always incomplete, and usually combined with a certain amount of external rotation. One or other condyle slips over to the opposite half of the tibial surface; the knee is always slightly flexed. To **reduce**, flex the thigh on the abdomen, extend the knee, and rotate slightly. 2. **Backwards.**—This may be either complete or incomplete. If complete, the ligamentum posticum, and the posterior crucial ligament, are ruptured; the limb is shortened and semi-flexed, and the head of the tibia can be felt in the ham. 3. **Forwards.**—This form occurs more frequently than the last-named dislocation. It is more dangerous also from pressure on the popliteal vessels by the lower end of the femur, which is found projecting into the popliteal space. There is shortening of the limb and a certain amount of rotation. To **reduce**, the thigh is semi-flexed and held firmly by one assistant, while another makes extension from the ankle joint, and the Surgeon manipulates the bones into position. In all cases of dislocation the joint must be kept at rest for two or three weeks by lateral splints. In cases which resist all the ordinary means of reduction division of the lateral ligaments has been practiced.

I. '**Subluxation**' **of the Knee** (Hey's '*internal*

derangement of the knee joint).—It is due to a partial disloeation of the *internal* semi-lunar eartilage usually; the cartilage slips away from its proper position under the internal condyle, so that the surfaees of the tibia and femur are brought into direet apposition. It usually oeeurs during walking from striking the toe against, or tripping upon, a stone. There is sudden, severe, sickening pain felt in the knee, and the joint remains semi-flexed. The edge of the cartilage can sometimes be felt projecting under the skin. To **reduce,** flex the joint, and, when the patient is off his guard, forcibly extend, rotating slightly, and at the same time press the thumb firmly on any tender spot. When the cartilage is reduced the power of extending at once returns. The synovitis induced by the accident must be treated on general principles; after it has subsided the leg must be used freely.

THE PATELLA.

This bone may be dislocated—1. **Outwards.**—This is the most common form, from the slope of the femur and quadriceps extensor, which pass downwards and inwards, making an angle with the ligamentum patellæ, which passes vertically downwards. When, therefore, the quadriceps is suddenly brought into play it tends to assume a straight line with the ligamentum patellæ, and jerks the patella itself outwards. The **causes,** therefore, are sudden muscular contraction, especially in those who have a tendency to knock-knee, or a blow on the inner side of the patella during *extension*—a similar blow during flexion would cause fracture. The patella rests on the outer surface of the external condyle with its inner margin directed forwards. The leg

is usually slightly flexed; very frequently the dislocation is only partial.

2. **Inwards.**—This form is almost unknown. To **reduce** the *lateral* dislocations—Place the patient on his back, flex the thigh on the abdomen, and extend the knee joint, so as to relax the quadriceps extensor, and then depress the edge of the patella which is further from the middle line, so as to raise the other edge and free the bone, when the quadriceps will at once pull it into position.

3. **Vertically.**—Usually the outer (Malgaigne), sometimes the inner edge, of the patella is twisted into the intercondyloid notch, and there fixed. The joint is completely extended. It is usually **caused** by sharp blows or severe falls on one side of the patella. To **reduce** is often a difficult matter, probably from the wedging of the bone in the notch, or else from its being held by a slit in the capsule. Chloroform will be necessary, so as to paralyse the muscles, when flexion, combined with sudden extension and manipulation will probably replace the bone. Division of ligaments and tendons should be avoided, as the division does no good, and may do a great deal of harm.

4. **Upward.**—This can only occur when the ligamentum patella is ruptured, when the quadriceps extensor pulls the bone upwards. The **treatment** is the same as that for fractured patella *(quod vide)*.

THE ANKLE.

Ankle Joint.—*Class*, Diarthrosis; *Sub-Class*, Ginglymus. **Ligaments**—(1) anterior, and (2) posterior—these two are very thin; (3) internal lateral or deltoid, from the apex of the internal malleolus to the scaphoid.

os calcis, and astragalus; (4) external lateral, which consists of three strong fasciculi—(*a*) the *anterior* passes from the anterior part of the external malleolus to the front part of the astragalus; (*b*) the *middle* passes from the tip of the external malleolus to the outer surface of the os calcis; (*c*) the *posterior* passes backwards horizontally from the pit on the inner side of the malleolus to the posterior surface of the astragalus. **Movements.**—The movements at the ankle joint are chiefly flexion and extension and dorsi-flexion. The normal position of the foot is supposed to be at right angles to the leg; *extension* is pointing the toes, *flexion* is bringing the foot back again to a right angle, and *dorsi-flexion* is when the foot passes the right angle and its upper surface approaches the front of the leg. There is also a certain amount of movement from side to side when the foot is extended, because the posterior part of the articular surface of the astragalus is narrower than the anterior, but in the *erect* position there is no lateral movement possible. There are other two movements spoken about as occurring at the ankle—viz., eversion and inversion; the first of these movements is not very free, the second form is much freer. In *eversion*, the outer border of the foot is raised and drawn outwards. In the production of this form of club foot *(talipes valgus)* there is, in the first instance, a tendency to obliteration of the arch of the foot so that the sole becomes perfectly flat *(talipes planus*, or flat foot), and as the disease advances, eversion of the foot takes place. The flattening of the foot is due to the relaxation of the ligaments that support the arches of the foot; the ligaments that support the *transverse* arch are chiefly the interosseous ligaments, between the cuneiform and

the cuboid bones; those that support the *longitudinal* arch are—(1) the long plantar ligament (inferior calcaneo-cuboid); (2) the short plantar ligament (the short calcaneo-cuboid); (3) the calcaneo-scaphoid ligament, which supports the head of the astragalus; (4) the plantar fascia also assists to maintain the arch; and (5) the tendon of the tibialis posticus, and the tonic contraction of the muscles of the sole. *Inversion* is a much freer movement. It takes place at three points—(1) to a slight extent at the ankle joint proper; (2) at the articulation between the astragalus and the os calcis, but chiefly at (3) the transverse articulation of the foot, that is, at the astragalo-scaphoid and calcaneo-cuboid articulations. We have an example of this form of movement in *talipes varus* where the foot is twisted inwards and the sole is contracted. **Flexors** of the ankle joint.—*Direct*—(1) the tibialis anticus, (2) peroneus tertius; *Indirect*—(1) extensor longus digitorum, (2) extensor proprius hallucis. **Extensors.**—*Direct*—(1) muscles of the calf (gastrocnemius, soleus, and plantaris): (2) tibialis posticus; (3) peroneus longus; (4) peroneus brevis. *Indirect*—(1) flexor longus digitorum; (2) flexor longus hallucis. Note that the indirect *flexors* of the ankle joint are *extensors* of the toes; while the indirect *extensors* are *flexors* of the toes. **Evertors.**—(1) the peroneus longus: (2) the peroneus brevis; (3) the peroneus tertius. **Invertors.**—(1) the tibialis anticus; (2) the tibialis posticus.

Flexion of the joint is limited by the posterior part of the deltoid ligament, by the posterior fasciculus of the external ligament, by the posterior ligament, and by the contact of the head of the astragalus with the tibia. *Extension* is limited by the anterior fibres of the deltoid

ligament, anterior and middle fasciculi of the outer, by the anterior ligament, and by the contact of the astragalus with the tibia behind.

The position of the **malleoli** and the **Scaphoid tubercle.** The internal malleolus is more prominent and more anterior than the external; but the external extends lower down, and its tip is about half an inch behind, and below the tip of the internal. The tubercle of the scaphoid is fully an inch in front of the internal malleolus. In effusion into the joint as in **acute synovitis,** the swelling first shows itself in front beneath the anterior tendons, and at each side in the interval between the anterior edges of the lateral ligaments and the tendon of the peroneus tertius on the outer side, and that of the tibialis anticus on the inner. In severe cases it may be possible to detect bulging of the thin posterior ligament, and obtain fluctuation on the two sides of the tendo Achillis. The foot usually assumes a position of slight extension (pointing of the toes), and some amount of inversion.

DISLOCATIONS.

By dislocation of the ankle is meant displacement of the trochlea of the astragalus, from the tibio-fibular mortise, the astragalus still retaining its natural relations with the rest of the foot. It may be dislocated in five directions—outwards, inwards, backwards, forwards, and upwards (in the order of frequency). They are usually *caused* by some violent and sudden twist of the foot, as treading on the edge of the kerbstone, or alighting from a height upon a lower level than expected, with some part of the foot, but not

flatly on the sole. The antero-posterior are produced by the sudden arrest of the foot during some violent impulse of the body, as in leaping from a carriage in motion, or by some great force applied to the foot when the leg is fixed.

1. **Outwards.—Caused** by a twist of the foot outwards, when the weak fibula snaps first, and then the internal lateral ligament of the ankle, or else the tip of the internal malleolus is torn off. (*a*) Incomplete form *(same thing as 'Pott's fracture')*. The astragalus is partly displaced from the tibia by a rotation on its own horizontal axis so that the outer edge of its superior articular surface is higher than the inner, and rests against the under surface of the tibia. The fractured point of the fibula is from one and a half to three inches or more above the external malleolus, that is, through the upper part of its triangular subcutaneous surface. The foot is everted by the force that caused the dislocation, by the three peronei muscles, as well as the weight of the limb, so that the foot almost looks directly outwards, while the heel is drawn up by the muscles of the calf. There is a marked projection on the inner side due to the internal malleolus, and on the outer side, in the site of the fractured fibula, there is a depression, as the broken ends are forced inwards. The strong inferior tibio-fibular ligament is not ruptured. (*b*) Complete Form *(same as 'Dupuytren's fracture')*. In this form either the inferior tibio-fibular ligament is torn, or else a strip of the tibia to which it is attached is torn off, while the ligament escapes rupture. The trochlear surface of the astragalus is completely displaced to the outer side of the bones of the leg and drawn upwards; the internal malleolus is sometimes

forced through the skin, thus making the dislocation compound. There is increased breadth of the ankle with shortening of the leg. The internal malleolus is further down and more prominent than it should be; the external malleolus goes up with the astragalus, and is also prominent but too high. The whole foot has a tendency to be rotated outwards.

2. **Inwards.**—This is caused by violence, the reverse of that which produced the previous dislocation. It is much rarer however, as the powerful internal malleolus resists the twist and very frequently, therefore, the only result is a 'sprained' ankle. Should this dislocation occur, the tibia, and sometimes the fibula as well, is broken from the sudden wrench given to the strong external lateral ligament, which, rather than give way itself, often snaps the fibula, the broken ends of which in this case are displaced outwards. It is always incomplete, and the astragalus rotates on its antero-posterior axis. The sole of the foot is inverted and the external malleolus is very prominent and almost touches the ground, and there is a depression on the opposite side of the ankle.

3. **Backwards.**—It is caused by jumping from a carriage in motion, or falling backwards while the foot is fixed. It may be complete or incomplete; if complete the lower end of the tibia rests on the neck of the astragalus and scaphoid, with the trochlear surface of the astragalus behind it. The foot seems too short, and the heel too long with a depression above it; the tendo Achillis is tense, and the toes are pointed downwards.

4. **Forwards.**—Less common than the last. It is usually incomplete, the tibia resting on some part of the articular surface of the astragalus, and not entirely

behind that bone. The foot is elongated, and the heel shortened and less prominent. The space in front of the tendo Achillis is occupied by a hard mass—the ends of the tibia and fibula. The tendo Achillis is lax, and not so prominent as usual.

To **reduce** these dislocations, flex the leg on the thigh, extend the ankle joint so as to relax the muscles of the calf and the tendo Achillis; one assistant must now hold the thigh firmly, another seizes the foot and pulls in the direction of the long axis of the leg, while the Surgeon, by manipulation and pressure, endeavours to replace the bone. In difficult cases it may be necessary to divide the tendo Achillis. After reduction the leg is to be placed in the box splint (see Fracture of the Bones of the Leg).

5. **Upwards.**—In this case the two bones are separated, and the astragalus forced up between them. It is **caused** by falls on the feet from a great height, the foot being at right angles to the leg, and neither flexed nor extended. It is to be **reduced** in a similar way to that adopted in the other cases of dislocation. Sometimes it may be found impossible to do it, nevertheless, by patience, a useful foot may result.

OTHER DISLOCATIONS OF FOOT.

Dislocations of the Astragalus.—In all dislocations of this bone the malleoli are nearer the sole than they should be.

1. **Forwards.**—The most common form. The astragalus is shot forward like an orange pip from between the finger and thumb, and rotated slightly at the same time—usually to the outer side. It may be complete or incomplete. A swelling is noticed to one or other

side, which is the round, globular head of the astragalus covered by tense skin; it may be possible to distinguish the outline of the bone. This dislocation is usually caused by a fall or twist on the extended foot.

2. **Backwards.**—This is caused by falls or twists on the flexed foot; it is rare. There is a hard prominence felt just above the heel, between the tendo Achillis and the malleoli. The foot seems shorter, and there is a prominence in front caused by the ends of the tibia and fibula.

3. **Lateral.**—If complete, must always be compound. If to the outer side, the foot is turned inwards, and there is a great projection of the external malleolus. If to the inner side, the appearances are reversed.

4. **Version.**—A rotation of the astragalus on its horizontal or vertical axis. The history of severe injury and the loss of movement must guide. To **reduce**, give chloroform and attempt reduction as in previous dislocations, by flexing the leg on the thigh, extending the foot, and then, by extension, counter-extension and manipulation forcing the bone back to its place. It may be advisable to divide the tendo Achillis or any other *tense* tendon. In impossible cases, put up in the best position, wait, and watch, and act accordingly. Should the skin threaten to slough over the head of the bone, it must be excised. Do not be in too great a hurry to amputate.

Subastragaloid Dislocations.—These are dislocations at the calcaneo-talo-scaphoid articulation. The astragalus maintains its normal relations with the tibia and fibula, whilst the rest of the foot is partially or completely disarticulated from it. The *foot* may thus be displaced forwards, backwards, or laterally; the usual

form is backwards, from a strain or twist. It is seldom, however, directly backwards; the foot is usually at the same time twisted outwards or inwards. If **backwards and outwards** the foot is everted and abducted, and the sole looks outwards; the inner malleolus and head of the astragalus are prominent, but the outer malleolus is not so prominent. If **backwards and inwards** the symptoms are reversed.

Laterally.—These are usually incomplete and often compound. In the *inward* form the appearance resembles that of *talipes varus*—the foot is inverted, its inner border is raised, shortened, and rendered concave, while its outer border is lengthened and convex. The head of the astragalus and outer malleolus form a marked projection on the outer side of the foot; the inner malleolus is buried and the whole limb seems shorter than natural.

In the *outward* form the reverse holds true. The appearance resembles that of talipes valgus; the foot is everted, its outer border is raised, shortened, and concave, while the inner is lengthened and convex. The outer malleolus is buried, while the tibia and head of the astragalus form a marked projection on the inner side.

The **treatment** must be conducted on the same principles as in dislocations of the astragalus.

CHAPTER XXIII.

FRACTURES OF THE UPPER EXTREMITY.

THE CLAVICLE.

Development.—The clavicle is developed from two centres—one for the shaft which appears very early (before any other centre, it is said); so early does the ossification begin and so rapidly does it proceed that the whole shaft is bony at birth. The other centre is for the sternal end, and appears from eighteen to twenty years, and joins the shaft about twenty-five.

The clavicle is subcutaneous, and any irregularity therefore, as in the case of fracture with displacement, is readily felt. It is more frequently broken than any other single bone in the body, although the radius almost runs it neck to neck, and it is more frequently the seat of *greenstick fracture* than any other bone. Statistics show that one-half the total number of fractures of this bone occur before the age of five years. Greenstick fracture is very often subperiosteal on account of the very thick and strong periosteum that covers the bone; it is important to keep this fact in mind, as there may be little or no displacement, and the incautious practitioner may state to the parents that there is no fracture. In a few days 'callus' is thrown out, forming a lump on the bone and leaving

no doubt as to the nature of the accident. Should the case *then* fall into the hands of an unscrupulous brother practitioner, qualified or otherwise, the first is very likely to be severely blamed and probably lose his patient as well. Therefore be cautious, and take care to explain well to the parents the probable or possible result. Fracture of this bone is very common, because —(1) It is much exposed to *direct* violence; (2) it is the only osseous connection of the upper extremity with the trunk. Its shape enables it to withstand, to a certain extent, *indirect* violence, the force being partially broken at each curve.

Causes.—(1) *Direct violence*—Fracture from this cause happens comparatively seldom; when it does take place the fracture is transverse and at the point struck. (2) *Indirect violence*—This is the usual cause, as in falls on the shoulder, elbow, or hand; the direction of the fracture is oblique, and as a rule is situated where the two curves meet, at the junction of the middle and outer thirds of the bone, as at this point the bone is more slender than elsewhere. In children and infants the usual cause is falling out of bed, or being dropped by a careless nurse. (3) *Muscular action* has been known to break the bone, as in using a whip; in this case the fracture is usually on the right side and about the middle of the bone.

FRACTURES OF THE CLAVICLE.

1. Fracture at the **Sternal End.**—Fracture at the sternal end takes place about three quarters of an inch from the end of the bone, internal to the rhomboid ligament, and is usually transverse. This may resemble a dislocation. The outer fragment is drawn towards

the sternum by the subclavius, and the pectoralis major and minor muscles.

2. At the **Junction of the Two Curves.**—This is by far the most common seat of fracture. The *outer* fragment is drawn downwards, forwards, and inwards—downwards by the weight of the arm and scapula, and the action of the deltoid and other muscles acting on the scapula, as the pectorals and latissimus dorsi; forwards by the pectorals and serratus magnus rotating it; and inwards by the pectoralis major and minor, subclavius and trapezius, and muscles attached to the posterior border of the scapula—levator anguli scapulæ, and the rhomboids, major and minor, also the latissimus dorsi; and at the same time the outer end is rotated forwards, whilst the inner end points backwards. The *inner* fragment seems raised, but this is because the outer one is depressed; it is practically kept in its natural position by the sterno-mastoid above, and the pectoralis major and rhomboid ligament below. In this fracture the patient cannot raise his hand to his head; he supports the injured limb with his other hand, and leans his head and body to that side to relax the muscles.

3. At the **Coraco-Clavicular Ligament.**—If the fracture takes place between the conoid and trapezoid ligaments, there will be little, if any, displacement. This fracture is often caused by direct violence, and it comes to be a question of diagnosis of this fracture from a mere *bruise* of the periosteum. In a *bruise* the pain is *diffused* and dull, there being no specially tender spot, and no sign or indirect pressure. In fracture the pain is severe and strictly localised to *one spot*, which can readily be detected by carrying

the finger along the bone from the sternal side; the *tender spot* is situated about the deepest part of the anterior concavity, immediately above the coracoid process. Further, there will be pain at this spot when firm pressure is made on the great curvature of the bone, at some distance to the inner side of the injured point, as the pressure makes the broken ends rub against each other (the *indirect method*). In a bruise, as the bone is not broken, there is no pain on applying this test. It may be possible to elicit crepitus on moving the shoulder.

4. It may be broken to the **outer side of the coraco-clavicular ligament,** when the small fragment is gradually drawn round by the pectoralis minor and major, and serratus magnus, these muscles depressing and rotating forwards the point of the shoulder, until it lies at a right angle with its shaft. By this means the shoulder is narrowed, and may drop a little from the weight of the arm; but, as a rule, there is little, if any downward displacement of the outer fragment, as it cannot fall without the scapula moving with it, but the scapula is slung up by the coraco-clavicular ligament, and therefore cannot fall down. This fracture is usually caused by direct violence. *Comminuted* fracture of the clavicle is dangerous because of its close relation to important vessels and nerves. The structures most likely to be wounded in fracture are the veins and the cords going to form the brachial plexus. Sir R. Peel in this way got a diffused false venous aneurism from an accident in the hunting field, which was ultimately fatal. Accidents of this kind are, however, fortunately rare, probably on account of the dense fascia which underlies the clavicle protecting the vessels from injury.

TREATMENT OF FRACTURED CLAVICLE.

The most certain method to secure union without deformity, is to keep the patient flat on the back in bed with a small pillow between the shoulders, for about three weeks, till the fracture unites; the head is placed on a thin pillow, and the arm bound to the side. In this position the blade of the scapula is pressed close against the ribs, and in this way its outer angle, with the humerus and acromion process, is pulled outwards and backwards, and the recumbent posture removes the weight of the arm which is the chief cause of the downward displacement. This plan may therefore be adopted in cases where it is specially desirable to avoid deformity, *e.g.*, in the case of young ladies. This plan *must* be adopted also in complicated and comminuted fractures, and in cases where both clavicles are broken at once.

1. For Fractures **internal to the Coraco-clavicular Ligament.**—Whatever plan is adopted it must fulfil three conditions; as to the exact method there is no hard and fast rules, provided the deformity is remedied. The conditions are that the shoulder must be drawn—(1) outwards; (2) upwards; and (3) backwards. (1) The shoulder may be drawn *backwards* by a figure-of-eight bandage round the shoulders and stitched behind. But this is objected to, because the front turns of the bandage may press on and displace the inner end of the outer fragment. (2) The *inward* displacement may be overcome by an axillary pad, which acts as a fulcrum to the upper end of the humerus, the shoulder being carried outwards when the elbow is pressed to the side. This also is objectionable, because of the compression

it exerts on the axillary vessels and nerves, causing great pain and œdema at first, and probably paralysis afterwards. (3) The *downward* displacement is best counteracted by raising the elbow. The arm is firmly fixed to the side by a broad domet bandage, and so guided that it will also support the elbow of the injured side. Or a special sling may be used.

(*a*) **By Three Handkerchiefs.**—(1) One, folded diagonally, is rolled round a pad of wool, and the pad is placed in the axilla of the injured side, the ends being crossed on the top of the opposite shoulder over a small pad, and thence under the axilla, which is also padded, and tied in front, over a small pad. (2) The second, also folded diagonally, is applied as a sling to support the *elbow*, and the base of the triangle is therefore applied to this point; the forearm is flexed at an acute angle and laid so that the fingers almost touch the shoulder of the opposite side. (3) The third, is applied round the trunk and elbow, so as to fix the arm to the side.

(*b*) **Sayre's Method.**—Two pieces of adhesive plaster spread upon strong calico or moleskin, about three and a half inches wide, or less, according to the size of the patient, and for an adult, about two yards in length. On one of the pieces a loop is made and *stitched*, which is passed round the arm of the injured side about its middle third; the loop must be quite loose, so as not to compress the vessels, and the non-adhesive side of the plaster next the skin. By means of this piece the arm is drawn well *backward*, and then the plaster is carried round the body one and a half times and the end stitched to the first turn. The second piece passes from the sound shoulder obliquely round the chest, the

injured arm being drawn well *forwards*, when the loop round the arm acts as a fulcrum, and the shoulder is thrown backwards and outwards; a slit is cut in this piece for the point of the elbow, which is at the same time pushed well upwards. The second piece is then fastened to itself over the sound shoulder; it must be long enough to complete this circumference once and leave about eight inches more.

2. Fractures **at the Coraco-Clavicular Ligament.**—All that is required is simply a broad domet bandage to fix the arm to the side for a couple of weeks.

3. Fractures **External to the Coraco-Clavicular Ligament.**—In this case there are only two displacements to counteract—forwards and inwards—and for this purpose the shoulders must be braced back and the arm fixed to the side. (*a*) **By figure-of-eight bandage** round the shoulders and fastened behind. This counteracts both the inward and the forward displacements. Or (2) **two padded handkerchiefs** may be used, carried round the axillæ from behind, over the tips of the shoulders, and tied, or *stitched*, at the back over a pad. The arm is then secured to the side as usual.

In adults, fractures internal and external to the coraco-clavicular ligament will unite in about *four* weeks; *at* the ligament *two* weeks rest will be sufficient. Fractures of the clavicle in children will unite in *three* weeks, and in infants in *two* weeks.

FRACTURES OF THE SCAPULA.

Fractures of the **body** of this bone are rare. When they occur all that is required is a thick, soft pad, and a broad bandage to steady the parts. The **Anatomical neck**, that is, of the glenoid cavity, external to the root

of the coracoid process. A fracture through the anatomical neck may simulate dislocation of the humerus; but by raising the arm the parts resume their natural appearance with the production of crepitus probably, but become displaced again when the arm is set free. The *treatment* is to raise the elbow, place a pad in the axilla, and bind the arm to the side.

Fracture through the **surgical neck**, that is, of the glenoid cavity, and passing through the supra-scapular notch, and internal therefore to the root of the coracoid process. As the powerful coraco-clavicular ligament is not ruptured, there can be no displacement, as the broken fragment is slung to the clavicle; hence there will be crepitus, but no deformity. One can only diagnose this condition by a process of exclusion (CHIENE). All that is required in the way of **treatment** is to place the forearm across the chest and bind the whole arm firmly to the side. Fracture of the **acromion process.**—Many of the cases of supposed fracture of this process are believed to have been instances of non-union of its epiphysial centres, which appear, one at fifteen, and the other at sixteen years, and unite sometime between twenty-two and twenty-five years of age. The **cause** is usually direct violence, as a blow on the tip of the shoulder, or it may result from the head of the humerus being forced upwards from a fall on the elbow. It is necessarily associated with dislocation of the acromio-clavicular articulation. The broken fragment is drawn downwards by the deltoid, though the strong periosteum opposes the tendency to great deformity; the arm feels as if it were dropping off, and is therefore supported by the other hand. The patient can neither raise nor abduct the arm. As the bone is

subcutaneous, by running the finger along the spine of the scapula, the fracture may be readily detected, and, by raising the arm, the deformity is removed, probably with the production of crepitus. The **treatment** is to support the elbow in a sling and fix the arm to the side.

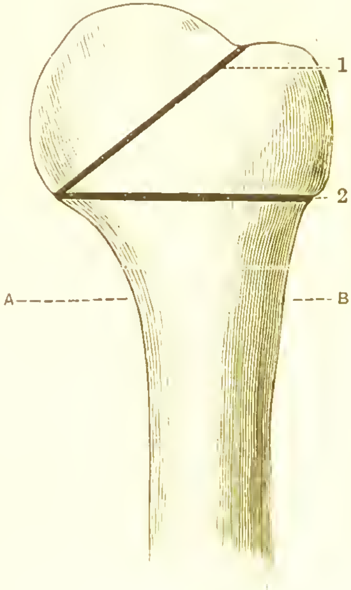
Fracture of the **coracoid process.**—Fracture of this process is rare, because of its depth, and because it is so well protected by neighbouring bones. Occasionally, however, fracture is produced by direct violence. Like the previous process, it may be merely the separation of an epiphysis; a centre appears during the first year near the tip of the bone, and unites with the rest from twenty-two to twenty-five years of age. If the fracture is external to the coraco-clavicular ligament, the detached fragment will be displaced downwards by the short head of the biceps and coraco-brachialis on the one hand, and the pectoralis minor on the other. If internal to the ligament there will be no displacement, as it will simply be slung up to the clavicle by the strong coraco-clavicular ligament. The **treatment** will be to bend the arm at an acute angle to relax the biceps, support the elbow, and bind the whole arm to the trunk.

THE HUMERUS.

This bone is developed by seven centres; that for (1) the shaft appears about the fifth week of fœtal life, and at birth the shaft is pretty well ossified though the ends are cartilaginous. (2) A centre for the head appears during the first or second years, and unites with the tuberosities in the line of the anatomical neck, about the age of five. Before five years of age, therefore, it will be possible to have a separation of

this epiphysis. (3) There is a centre for the tuberosities which appears during the second or third years, and after being joined by the head of the bone, unites with the shaft at twenty years of age, the line of union being considerably above the surgical neck, so that

Fig. 26.



UPPER END O UMERUS.

1. Epiphysial cartilage in the line of the anatomical neck, which joins the tuberosities at five years of age. 2. Epiphysial cartilage between the tuberosities and shaft, which unites with the shaft at twenty years of age. A. B. Surgical neck.

from five to twenty years of age we are more likely to have a separation at this line than fracture of the surgical neck (Fig. 26). At the lower end there are other four centres appearing at various ages, and all, save that for the internal condyle, uniting with the

shaft at sixteen or seventeen years of age. That for the internal condyle is the last to unite, union taking place a year or so later—at eighteen years.

The humerus is most thickly covered by muscles on its anterior and posterior aspects, and fractures are best detected by running the fingers and thumb along the *sides* of the bone. The shaft is very often the seat of ununited fracture; this was well seen in the case of the late Dr David Livingstone, the African Missionary and Explorer, about the middle of whose left humerus a pretty complete false joint had formed. The cause of non-union of the humerus is doubtful, but it is probably to a great extent due to imperfect fixing of the joints above and below the fracture. Some say it is because the elbow is usually left unsupported during the after treatment of the case; others, that it is due to the inclusion of some muscular tissue between the broken ends, which is very likely to happen since the bone is so closely enveloped by muscles—the brachialis anticus and triceps especially. The **causes** of these fractures are—(1) *Direct violence*, the usual cause of fractures at the upper end; (2) *indirect violence*, as falls on the hand or elbow; (3) *muscular action;* the humerus is said to be more frequently fractured from this cause than any other bone in the body. It is usually the shaft that is thus broken, as in throwing a ball or striking a blow straight from the shoulder, when the humerus gives, either from the actual force of the blow, or else from the object having 'dodged' it.

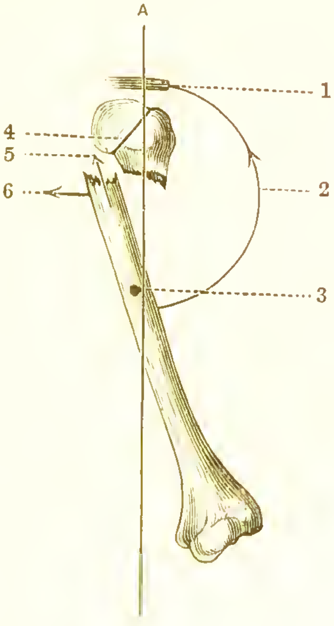
Fractures of the **Anatomical Neck.**—These may be impacted or unimpacted; in the first case the head of the bone is driven into the cancellous tissue of the upper end of the humerus; in the non impacted the head lies

loose, like a foreign body in the joint, a condition far less favourable to union than the impacted variety. Before five years of age it is merely a separation of the head at the epiphysial line. Fractures of the anatomical neck are caused by severe direct violence, as falls or blows on the shoulder, usually in old people. The signs are not very definite; by the finger in the axilla the surgical neck can be felt entire, but still crepitus is elicited on moving the shaft of the humerus, and it may be possible to feel the detached head. There is further, pain, slight flattening of the shoulder, loss of movement, and probably slight shortening.

Fracture of the **Surgical Neck**, that is, below the great tuberosity, but above the muscles inserted into the bicipital groove. It may be impacted or non-impacted; it is the most frequent fracture in this region, and is usually transverse in direction. In the prime of life it is usually **caused** by direct violence, but in the old it may result from indirect violence as a fall on the elbow or hand. As already stated, separation at the epiphysial line between the tuberosities and the shaft can only occur before the age of twenty. This line does not correspond to the surgical neck, but is considerably above it. In this case the upper fragment of the bone remains in the glenoid cavity, while the upper end of the lower fragment is drawn inwards and upwards, and forms a marked projection just beneath the coracoid process, rounded and smooth in outline, and when crepitus can be detected it is softer in character than ordinary crepitus. Fracture proper through the surgical neck is recognised by the shortening, crepitus, distortion, the axis of the bone being directed downwards and outwards, and loss of power of the

arm, while the shoulder is rounded and swollen. The shaft of the bone moves independently of the head when the elbow is rotated, and by pushing the fingers up into the axilla the upper end of the lower fragment may be detected. The elbow can be brought

Fig. 27.



FRACTURE THROUGH SURGICAL NECK.

1. Acromion process. 2. Deltoid muscle. 3. Imaginary pivot round which the humerus is rotated by the deltoid, throwing the elbow outwards and the upper end inwards. 4. Anatomical neck. 5. Forces that displace the bone upwards—biceps, triceps, coraco-brachialis, &c. 6. Forces that pull the bone inwards—pectoralis, major, latissimus dorsi, and teres major. A. B. Axis of unbroken humerus.

to the side while the hand is placed on the opposite shoulder. The upper end of the lower fragment can be felt under the coracoid process, especially when the elbow is pushed up and rotated. The *upper* fragment,

together with the head of the bone, is rotated outwards, abducted, and raised by the muscles attached to the greater and lesser tuberosities—supra- and infra-spinatus, teres minor, and subscapularis; still, the displacement of this fragment is not great, because the muscles of the two tuberosities almost counterbalance each other. The only muscle not balanced is the supra-spinatus, which may, therefore, sometimes cause persistent abduction of the fragment. The *lower* fragment is drawn, upwards, inwards, and forwards—upwards by the biceps, triceps, and deltoid; inwards and forwards by the pectoralis major, latissimus dorsi, and teres major. The axis of this part also is altered, the elbow being tilted outwards by the action of the deltoid (Fig. 27.) At first sight this injury may seem to resemble sub-glenoid dislocation of the head of the humerus; but the head of the bone can be felt in its natural position, the limb is *shortened*, and there is increased mobility, and we may easily elicit crepitus. Further, the depression in fracture is not immediately under the acromion process as in dislocation, but at some distance below this point—below the lower end of the upper fragment, a little above the insertion of the deltoid. In *impacted* fracture there is no mobility, displacement, nor crepitus. In this case the lower fragment usually penetrates into the cancellous tissue of the superior—the reverse of impacted fracture of the anatomical neck. The signs of this condition are obscure, and chiefly of a negative character.

TREATMENT.

Treatment of fractures and diastasis of the necks of the humerus—(1) 'Set' the bones by extension; (2)

place a pad in the axilla to keep the upper end of the lower fragment outwards; (3) bend the elbow to a right angle, and keep the upper arm parallel with the side of the chest, and rather in advance of the mid-axillary line, so as to counteract the forward displacement of the upper end of the lower fragment; (4) use a sling to support the *hand* only, so that the weight of the limb may overcome the upward displacement. The late Professor SPENCE taught that the elbow should be supported, so as to keep the ends of the bone in apposition, and secure firm union; (5) the arm must then be tightly bandaged to the trunk by a broad domet bandage. Some advise that the hand and forearm should be bandaged lightly so as to avoid venous congestion. No splints are required, but if necessary a gutta-percha cap may be moulded over the shoulder and upper part of the humerus, to steady the parts, especially in the case of children or restless patients; or the cap may be made of moulded 'poroplastic' material, with a rectangular splint attached, of the same material, to pass along the outer side of the arm and forearm as far as the wrist; this will insure perfect rest to the injured bone. The fingers and wrist should be left free, and passive movement practiced occasionally lest the tendons stiffen. The fracture unites in from four to five weeks in youth, but requires longer in old age—two to five months.

THE GREAT TUBEROSITY.

Separation of the Great Tuberosity.—This may be caused by falls or blows on the shoulder, or from powerful contraction of the muscles inserted into it. The separated fragment is carried outwards and upwards

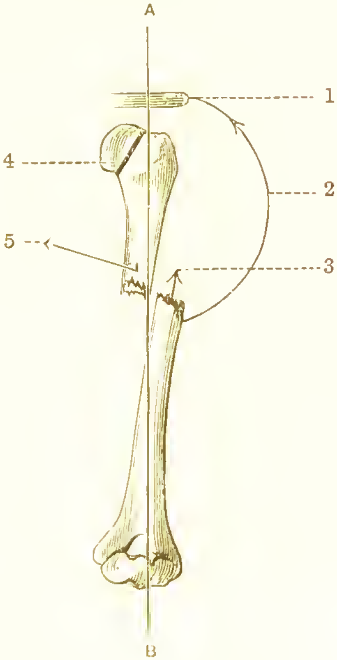
by the three muscles attached to it—supra-spinatus, infra-spinatus, and teres minor; while the other part of the head with the shaft of the bone is drawn upwards and inwards by the muscles passing from the trunk and scapula to the arm—subscapularis, pectoralis major, latissimus dorsi, and teres major—as well as the flexors and extensors—triceps, biceps, and coraco-brachialis. There is flattening and great widening of the shoulder, with a double projection and a groove between. The anterior projection rotates with the shaft of the humerus, but the posterior projection does not. The treatment is to pad the axilla to throw the anterior fragment into its proper place, and then by a compress behind, the detached fragment is pressed into apposition; or the patient may be kept in bed, and the muscles displacing the parts relaxed by raising and abducting the arm.

SHAFT OF HUMERUS.

Fractures of the shaft of the humerus are usually transverse, but may be oblique from above, downwards and outwards, and the brachialis anticus and biceps muscles in front, and the triceps behind, cause a certain amount of displacement and shortening, by making the parts glide over each other. The shortening, however, is not usually great on account of the weight of the arm; the usual amount is about three-quarters of an inch. The usual causes are direct violence, indirect violence, as a fall on the elbow, or muscular action. If the fracture be transverse there may be no displacement, only a slight angling. If fractured at a point between the insertion of the deltoid below, and the muscles in the bicipital groove above, the *lower* fragment will be drawn upwards by

the deltoid biceps and triceps, and glide to the outer side of the *upper* fragment, which will be drawn towards the chest by the muscles in the bicipital groove—pectoralis major, latissimus dorsi, and teres major (Fig. 28).

Fig. 28.



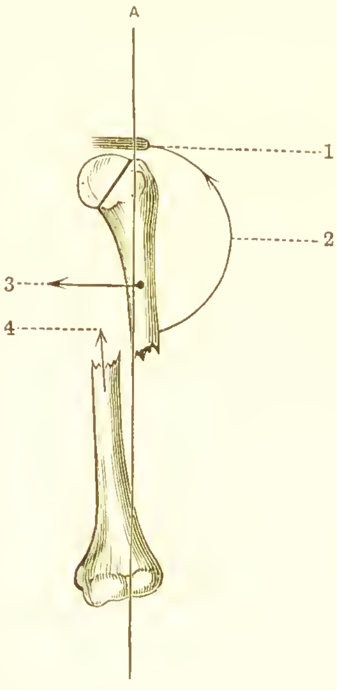
FRACTURE ABOVE THE DELTOID.

1. Acromion process. 2. Deltoid muscle, tilting the lower fragment outwards. 3. Forces that displace the bone upwards—biceps, triceps, &c. 4. Anatomical neck. 5. Forces displacing the lower end of the upper fragment inwards—pectoralis major, latissimus dorsi, and teres major. A. B. Axis of unbroken humerus.

Fractures below the Deltoid Impression.—The upper fragment is abducted by the deltoid and supraspinatus, while the lower fragment is drawn upwards and to its inner side by the biceps and triceps (Fig. 29).

Treatment of Fractures of the Shaft.—Two Gooch's splints sufficiently broad to almost completely surround the arm when padded. From the upper and anterior angle of the outer one a triangular piece should be cut

Fig. 29.



FRACTURE BELOW THE DELTOID.

1. Acromion process. 2. Deltoid muscle, displacing the lower end of the upper fragment outwards, in spite of the muscles inserted into the bicipital groove. 3. Muscles in the bicipital groove—pectoralis major, latissimus dorsi, and teres major. 4. Forces that displace the lower fragment upwards and inwards—biceps, triceps, coraco-brachialis, and brachialis anticus. A. B. Axis of unbroken humerus.

off in order to allow the splint to be carried well up over the point of the shoulder, which could not be done were the upper end cut square, as the anterior corner

would hitch against the anterior fold of the axilla. This external splint must be long enough to reach from the tip of the shoulder to the lower end of the elbow when the arm is bent; a rectangular slice must be cut out of its anterior inferior corner—*i.e.*, from its *inner* side. The inner is cut nearly square at the top, or slightly scooped out, but a like slice, to that cut from the outer splint, is cut from its *outer* and lower corner. Both splints are to be well padded, especially the upper end of the inner splint. The elbow is bent at a right angle, and the forearm fits into the gap at the lower ends of the two splints to which it is fastened by a few figure of eight turns of bandage. The splint above this is to be fastened with slip knots, the forearm slung, but the elbow left unsupported. Instead of using two splints of the same shape, the external one may be made like the above, and the internal simply a narrow, straight piece of board with a piece cut from its lower end to avoid pressure on the internal condyle.

It is important, however, in all cases to fix both the elbow and shoulder joints either by an external or internal rectangular splint. Should an internal one be used, care must be taken not to press unduly on the axillary vein, or the internal condyle; a hollow pad must be placed over the internal condyle, or else a hole cut out of the splint. If an external one be used it must be carried from the acromion process to the hand, and its upper part expanded in order to envelope and steady the shoulder. It is most convenient to make the rectangular splints of poroplastic. In Mr Erichsen's *Surgery* great stress is laid on the fact that the elbow is to be supported in cases of fracture of the shaft of the humerus, as otherwise it is stated non-union

is apt to take place. But we fancy that the real cause of non-union in most cases is, because the joint on each side of the fracture has not been thoroughly commanded. Fractures of the shaft unite in from four to six weeks according to the age of the patient.

FRACTURES NEAR THE ELBOW.

Fracture just above the Condyles.—This fracture occurs chiefly in young persons; the usual **cause** is a fall on the semi-flexed elbow. This may be confounded with **separation of the epiphysis** in children, or **dislocation of both bones of the forearm backwards;** but the presence of crepitus, the fact that the limb assumes its normal appearance on extension, but becomes distorted again when the extension is discontinued, the increased mobility, and the *guide* already mentioned—viz., the relation between the internal condyle of the humerus and the olecranon process, will aid the diagnosis, both in fracture and separation of the epiphysis. In separation of the epiphysis there is no crepitation, or very soft in character, but the age of the patient, under sixteen, will guide us here. The lower fragment is carried backwards and upwards behind the upper fragment by the triceps muscle, just as in fracture proper, but the anterior projection is broader and more rounded than in fracture.

In **fracture proper** the displacement is very similar to the above, the lower fragment is pulled upwards and backwards behind the upper, and carries the forearm with it; so that the olecranon projects unnaturally, and there is a hollow above it. The lower end of the upper fragment is tilted forwards, forming a prominence in front, *above* the crease in front of the elbow joint (in

dislocation of both bones backwards the prominence is below this crease). In fracture also, the distance between the acromion process and the condyles is lessened, but not so in dislocation. So also the mobility, crepitus, and the fact that the deformity is easily reduced by extension, and the absence of any change in the relative positions of the various bony points around the joint should prevent the student mistaking this accident for dislocation of both bones backwards.

Treatment.—Set the bones by extension of the arm and forearm and press the lower end of the humerus backwards and the lower fragment forwards, and then bend the elbow to an acute angle. In this way the triceps behind acts as a posterior splint, and keeps the lower fragment pressed forward; next place a pad of cotton wool in the bend to exert counter-pressure and keep the lower end of the upper fragment backward. The elbow is then to be bandaged by successive divergent figures-of-eight sufficient to secure it in this position, and the arm then carried in a sling midway between pronation and supination, or else bound firmly to the trunk. Begin gentle passive movement *early*; the seat of the fracture can be secured between the fingers and thumb of the one hand while the other moves the forearm. Being near the spongy end of the bone there is but little danger of non-union.

Fracture of the Condyles.—This usually results from direct violence, such as falls or blows, or from muscular action. The inner one is more often fractured, and the detached piece (when the 'epicondyle' alone is broken) is carried downwards and outwards by the muscles attached to it. The signs are pain, impairment of motion, mobility of the fragment, and crepitus. In

cases where the articular surface is involved in fractures at the lower end of the humerus, they are almost always followed by some permanent damage to the joint, unless very great care be exercised in their diagnosis and after treatment. The joint may be involved by fracture of either condyle, or transverse fracture of the lower end of the humerus, with a vertical fissure between the condyles running into the joint—the T-shaped fracture. All these forms are usually produced by falls on the bent elbow. In fracture of the external condyle the fissure is usually situated between the capitellum and the trochlea; of the internal it runs through the centre of the trochlea. In the T-shaped fracture the width between the condyles is increased, and by grasping the condyles each can be moved independently of the other with the production of crepitus. In fracture of the internal condyle into the joint, the fragment is dragged upwards and inwards and carries the ulna with it, so that the relation between the internal condyle and the olecranon process is normal, but not so its relation to the external condyle; there is also a marked increase in the antero-posterior breadth of the condyle. This is very frequently associated with dislocation of the head of the radius backwards.

Treatment of these Fractures.—As there is usually considerable swelling and inflammation of the joint the usual means must be taken to allay the inflammation: after this get the bones into proper position by extension and manipulation, and then put up the limb with the arm at right angles to the forearm and the hand midway between pronation and supination. For this purpose some use a jointed rectangular splint on

the inner aspect of the forearm. But probably the best way is to apply two moulded poroplastic rectangular splints of such a size as almost to envelope the arm when padded. The arm is then supported in a sling. Begin passive movement *very early*, within SEVEN days (HAMILTON), in case the joint be stiffened either by fibrous adhesions, union of the detached parts in wrong positions, or else by the excessive production of callus adhering to the articular surfaces.

NERVE LESIONS.

Nerve Injuries following fractures of the humerus.—In fractures of the shaft of the humerus, the musculo-spiral nerve may be injured, either directly at the time of the accident, or later by the 'ensheathing callus.' Lower down, at the external condyle, the posterior interosseous branch alone may be injured. If the **trunk of the musculo-spiral** be injured, supination is imperfect, extension of the hand and fingers is entirely lost, and the hand therefore becomes pronated, and 'wrist drop,' somewhat resembling that seen in lead palsy, ensues. As the biceps, however, is not paralysed, a certain amount of supination is still possible. But the *lumbricales* and the *interossei* are not paralysed, so that the upper two joints of the fingers, if forcibly bent, may be again extended, as these muscles are supplied by the median and ulnar nerves, and their function is to flex the first phalanx, and extend the other two. It is to be distinguished from lead poisoning by the history of the case—occupation, blue line on gums (from the sulphide of lead), colic, trembling of the muscles previous to their actual paralysis, and by the early appearance and well marked character of the 'reaction

of degeneration,' as shown by the continuous current. In lead poisoning, curiously enough, the supinator longus muscle is not affected; this can readily be shown by placing the hand midway between pronation and supination, and pressing down the upper edge of the hand while the patient attempts to bend the elbow, when the muscle will be seen as a distinct resisting band. The 'reaction of degeneration,' and atrophy (from the loss of trophic influence, and not from disuse alone), also result from lesions of the nerve trunks, but not so rapidly as in lead poisoning. The following **fourteen muscles** are supplied by the musculo-spiral nerve, either directly or indirectly—(1) Biceps; (2) triceps; (3) anconeus; (4) supinator longus; (5) extensor carpi radialis longior; (6) extensor carpi radialis brevior; (7) extensor communis digitorum; (8) extensor minimi digiti; (9) extensor carpi ulnaris; (10) extensor ossis metacarpi pollicis; (11) extensor secundi internodii pollicis; (12) extensor primi internodii pollicis; (13) extensor indicis; (14) supinator brevis.

In paralysis of the **posterior interosseous** alone, in injuries involving the external condyle, there is only partial loss of supination and extension, as the supinator longus and extensor carpi radialis longior are not affected, being supplied directly from the trunk of the musculo-spiral. Should this condition last any length of time, the paralysed muscles tend to increase in length from the constant tension of the still healthy muscles, while the latter in like manner shorten as they have nothing to oppose them, consequently the fingers become flexed and the hand crumpled up into a '*club-hand*,' somewhat resembling that seen after bad

cases of teno-synovitis, or in contraction of the palmar fascia. The muscles supplied by the posterior interosseous nerve are from six to fourteen, inclusive, of the list given under the musculo-spiral nerve.

In fractures of the internal condyle the ulnar nerve may be implicated in a similar way. In this case there will be great loss of power in the ring and little fingers, adduction and flexion of the thumb will be imperfect, and adduction and abduction of the index and middle fingers impaired, as the interossei are paralysed. The muscles paralysed are—(1) flexor carpi ulnaris; (2) half of the flexor profundus digitorum; (3) the three short muscles of the little finger—the abductor, flexor brevis, and opponens minimi digiti; (4) one and a half muscles of the thumb—adductor pollicis, and deep head of the flexor brevis; (5) all the palmar and dorsal interossei; (6) the two inner lumbricales.

To treat these conditions mechanical means must be used so as to prevent further deformity, and remove that already existing, passive motion, massage and galvanism to the paralysed muscles. In cases where the nerve is actually enveloped in bony outgrowths it will be necessary to cut down and set it free. The musculo-spiral nerve may also be paralysed, partially at least, in those who use crutches (*'crutch palsy'*) from pressure of the upper end of the crutch upon the nerve trunk; also by the axillary pad, in cases of fracture of the surgical neck of the humerus; lastly, in those who have imbibed too much of the cup that cheers (?) and most certainly does inebriate, and have fallen asleep in consequence, with one arm hanging over the back of a chair. This last form (*'Saturday night palsy'*) is peculiarly apt to be first discovered on Sunday morning,

the patient usually applying for advice and explanation on the following Monday. The best treatment for this last condition is electrical stimulation to the muscles, and stimulation of the nerve trunk, by applying some counter-irritant to the skin over the course of the nerve, *e.g.*, Iodine, and to avoid the cause.

BONES OF THE FOREARM.

Each of the bones of the forearm is developed from three centres. The centres for the shafts appear very early in fœtal life. The *radius* has also a centre for the head that appears at five years of age and joins the shaft about puberty, and another for the lower extremity which appears about the second year and joins the shaft at twenty years of age. The *ulna* has a centre for the olecranon process, appearing at the tenth year and joining the shaft about puberty; and another for the lower extremity appearing at the fourth year, and, like the radial one, joining the shaft at twenty. Hence it will be noticed that in both cases the upper epiphyses join the shafts at puberty, and the lower at twenty; and that the two centres for the ulna appear at exactly *double* the age as that for the radial centres—radial, five and two; ulnar, ten and four. Next to the clavicle, the bones of the forearm more frequently present examples of *green-stick* fracture than other bones, usually the result of a fall on the hand or a twist of the arm in a young person. In adults either may be broken alone, but fracture of both together is far more common. The lower end of the radius is not included in the previous statement of course; if it were then fracture of the radius alone occurs more frequently than fracture of any other bone, the clavicle perhaps

excluded, and at the lower end the fracture is very often impacted. The bones are throughout nearer the posterior than the anterior surface of the limb, and as the wrist is approached the nearer the two bones come to the surface of the lateral aspects of the arm. The posterior edge of the ulna is subcutaneous from the olecranon process to the wrist, and can therefore be readily examined in cases of supposed fracture. The upper-third of the radius is pretty deeply covered, though its *head* is quite superficial just immediately below the external condyle of the humerus; in the lower two-thirds it is quite subcutaneous on its outer aspect. However, fractures of this bone are best detected by noting whether the head of the bone follows the movements of the wrist during pronation and supination, the thumb of the left hand being placed on the head of the radius.

The Olecranon Process.—The olecranon process may be fractured by the action of the triceps muscle, or by fall, or blow with a stick, on the bent elbow. It occurs most frequently in men during the mid period of life. The fragment is carried up by the triceps, and there is a hollow at the back of the joint, which is increased during flexion; and there is partial or entire loss of extending power. In some cases the dense periosteum, strengthened by a ligamentous expansion from the triceps muscle, is not torn, and in these cases there will be little or any displacement; the only symptom, being special tenderness in the line of the fracture and probably mobility and crepitus—the upper fragment moving on the lower.

Treatment.—The indications are (1) to keep the triceps muscle relaxed, to enable (2) the detached

portion to be brought into and kept in its natural position by mechanical means—in other words the arm must be kept extended during the healing of the bone. This is the *only* injury in the region of the elbow joint that should be treated in this position; all other injuries here are best treated in the flexed position. A splint, not exactly straight, but cut so as to correspond to the angle made by the forearm with the upper arm, is required; it may be made of wood, Gooch splint, or gutta-percha, and should be long enough to reach from the middle of the upper arm to the wrist. The splint, as usual, must be well padded. *Before* applying the splint, in this special fracture, the fingers must be carefully padded, and the forearm and hand bandaged in the ordinary way, from the tips of the fingers upwards, finishing off with a *very lightly* applied figure of eight round the elbow, merely to retain the end of the bandage, and not to exert any pressure upon the joint. The arm is to be thus bandaged to prevent venous congestion, which is apt to take place since the limb is kept in the extended position; and as the joint is wounded, synovitis will almost certainly take place, hence the importance of avoiding tight bandages round the joint under the splint. The splint is then to be applied along the front of the limb, and bandaged to it in the usual way; and lastly apply a few turns of a figure-of-eight bandage over the olecranon, so as to press the fragments together, at first not very tightly, but as the swelling and effusion into the joint subside, more firmly.

Probably some form of gentle elastic traction brought to bear on the upper fragment alone, as it only is displaced, would be the most effective plan—something of the nature of MANNING'S splint for fractured patella.

The splint may be kept on for two or three weeks, and after this gentle passive movement practiced, and a week or so later the splint may be entirely abandoned. The union is usually fibrous, bony being rare. In cases where the fibrous medium is too long it may be removed by operation, and the fragments wired together.

Fracture of the **coronoid process.**—This is very frequently associated with dislocation of the ulna alone, or of both bones backwards. It arises from falls on the palm with the elbow slightly flexed. The detached fragment will be pulled upwards by the brachialis anticus muscle. Fractures of the **head and neck of the radius** are very rare forms of accident. In fractures of the neck, the upper end of the lower fragment will be pulled forwards by the biceps muscle. The upper epiphysis may also be separated before the age of puberty. The **treatment** of these injuries is the same as that for fracture of the condyles of the humerus, *quod vide.*

Fracture of the **radius alone above the insertion of the pronator radii teres.**—When the radius alone is fractured it is usually the result of *indirect* violence as a fall on the hand. The upper fragment is flexed by the biceps, and fully supinated by the same muscle, and the supinator brevis; while the lower fragment is fully pronated by the pronator radii teres and the pronator quadratus. Hence the upper part is fully supinated, while the lower is fully pronated. It is important to bear this in mind while treating the case, as first pointed out by LONSDALE.

Fracture of the same bone **Below the Insertion of the Pronator Radii Teres.**—In this case the upper fragment is drawn upwards; or, rather, it is tilted

forwards by the biceps and inwards by the pronator radii teres. The displacement inwards, however, may not be great, as the pronator radii teres is powerfully opposed by the supinator brevis, so that the bone retains a position midway between pronation and supination. The lower fragment is drawn towards the ulna, and pronated by the pronator quadratus, while the supinator longus tilts up the styloid process and depresses the upper end of the fragment.

Fracture of the **Ulna Alone near its Middle.**—This is usually the result of *direct* violence, as the bone is so superficial, as in carrying something in the hands, *e.g.*, a tray, when the foot slips, and, to save the contents of the hand, the whole force of the fall is received on the posterior edge of the ulna. So also it may be broken by a blow from a stick when the arm is held up to protect the head; or in falling against the edge of a doorstep. In this case there is but little displacement of the upper fragment, except that it is drawn a little nearer the radius by the pronator radii teres; the lower fragment is drawn towards the radius by the pronator quadratus, and the extensors and flexors tend to draw it upwards. Although the displacement due to muscular action, may not be great, yet the force that breaks the bone may cause a good deal, as it forces the broken ends towards the radius.

Fracture of **Both Bones.**—The bones of the forearm are more frequently broken together than either the radius or ulna alone. The usual **cause** is *direct* violence, as a severe blow, or the passage of a wheel over them, and they, therefore, give way opposite each other. But it may also be caused by *indirect* violence, when the bones give way at their weakest parts. One case is

quoted, on the authority of MALGAIGNE, where muscular action, during digging, was the cause of the fracture —surely it must have been for hid treasure. The usual position of the fracture is about the middle or lower thirds. As regards the displacement this will necessarily depend a good deal on the cause of the fracture; in a general way, something like the following will happen:—The *upper* ends.—The *radius* is tilted forwards by the biceps, and inwards by the pronator radii teres, and the ulna is tilted a little forwards by the brachialis anticus. The *lower* fragments.—The *radius* is pronated, and the two bones are approximated by the pronator quadratus, and are drawn upwards and forwards, or upwards and backwards, according to the obliquity of the fracture, by the flexors and extensors. The diagnosis depends on the pain, loss of power, unnatural bend of the forearm, crepitus, &c.

TREATMENT.

Treatment of Fracture of the Shafts of One or Both Bones.—The great objects are—(1) To keep up the full breadth of the interosseous space throughout, as this is essential to the movements of pronation and supination; (2) to command the elbow and wrist joints, in order to prevent non-union. The bones are to be set by extension and counter-extension, applied to the upper arm and wrist by two assistants, while the Surgeon manipulates the bones into position. Two splints are required, rigid, and *broader* than the arm; Gooch, or ordinary wooden splints may be used, but if Gooch be used, the splints must be padded on the *wooden* side, and not on the leather side as in most cases of fracture—*e.g.*, of the humerus. They must be

broader than the arm so as to prevent pressure by the bandages on the lateral aspects of the bones, as this would force them together and narrow the interosseous space. The posterior one must reach from the olecranon process to the tips of the fingers; the anterior one must reach from the elbow (when that joint is bent at right angles) to the roots of the fingers. They must be well padded as usual, but in addition a thick long 'graduated compress' like pad is to be placed lengthwise in front and behind, so that it may press into the interosseous space and keep the bones from falling together. The hand is then placed midway between pronation and supination, as in this position of the bones the interosseous space is widened to nearly its fullest possible extent; the elbow is next bent to a right angle, the graduated compresses applied over the front and back of the interosseous space, and the splints applied and fastened by a continuous bandage, to finish off by a lightly applied figure-of-eight round the elbow—if preferred slip knots may be used instead as in the upper arm. The arm must then be slung in a position midway between pronation and supination—the thumb uppermost, and pointing towards the patient's face. Over all an external rectangular splint should be applied to insure perfect immobility of the broken ends.

But inasmuch as the power of supination is sometimes lost, it is said from the union of the radius in a bad position, the upper fragment being fully supinated while the lower is fully pronated, it was first recommended by LONSDALE, and more recently by MALGAIGNE, that the arm should be put up in complete supination, since it is impossible to bring the upper fragment of the radius into good position with the

lower, the next best thing to be done is to carry the lower fragment into as good position as possible with the upper. This is best accomplished by the position of full supination.

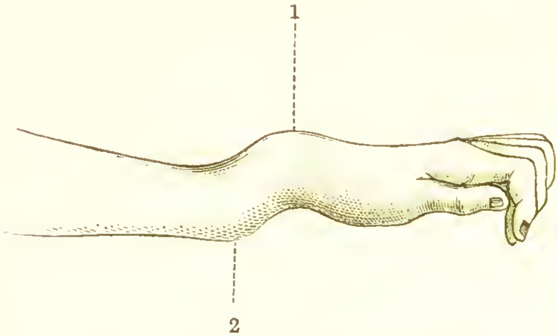
The limb must be kept perfectly rigid for at least two weeks, when the fingers and wrist may be allowed some freedom of movement. But as the fracture is not near a joint there is less danger of adhesions forming in the sheaths of the tendons; indeed, absolute rigidity rather is indicated, as the fracture is through the compact tissue of the shaft, to avoid non-union. The bones unite in about five weeks.

COLLES'S FRACTURE.

Fracture of the **Lower End of the Radius.**—The fracture in this case is usually about three-quarters of an inch, or rather more, above the articular surface, as seen from the front, but extends higher up on the posterior surface, as it is usually oblique from before backwards. The **cause** is usually *indirect* violence, as a fall on the palm of the outstretched hand, the whole weight of the fall being transmitted through the radial side of the hand to the lower end of the radius. The fracture may be unimpacted, but is usually impacted. Next to fracture of the clavicle, the lower end of the radius is most frequently broken. From thirty years of age onward it occurs with increasing frequency in women. The *lower* fragment is drawn upwards and backwards by the supinator longus, flexors, and extensors of the thumb and carpus; the *upper* fragment is not displaced (CHIENE), though it seems to project forward. Thus we have a prominence on the back of the wrist and a hollow above it, caused by the lower

fragment, and a projection in front, where there ought to be a hollow caused by the lower end of the upper fragment, the whole forming a peculiar spoon-shaped deformity (Fig. 30). It resembles dislocation of the carpus backwards, but may be distinguished from it by the fact that the deformity is removed by extension, and by the presence of crepitus, and the normal relation of the styloid processes. It also simulates separation of an epiphysis, but the age of the patient will aid the

Fig. 30.



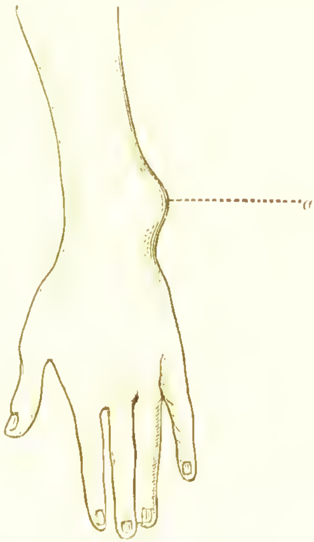
COLLES'S FRACTURE—SIDE VIEW.

To show the 'spoon-shaped' deformity. 1. Prominence on the back, caused by the lower fragment, with a depression above it. 2. Prominence on the anterior aspect, caused by the lower end of the upper fragment, with a depression below it.

diagnosis. But the lower fragment, besides being displaced upwards and backwards, undergoes a rotation on its transverse axis, whereby the carpal articular surface comes to have an inclination backwards instead of forwards, as in the normal bone. It is also slightly rotated on its antero-posterior axis, whereby the outer (radial) side of the bone is more shortened than the inner (ulnar) side, as the strong inferior radio-ulnar ligaments oppose the displacement at that side, and it is in this

way that the hand is inclined to the radial side, as well as being slightly dorsi-flexed. The head of the ulna seems unduly prominent (Fig. 31), but this is not due to any displacement of the bone, but is due to the hand being displaced to the radial side. The fracture is to be recognised by the appearance of the hand, history of the case, age of the patient, and by the fact that he is unable to supinate the forearm, and, by passing the

Fig. 31.



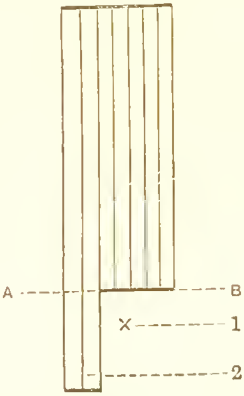
COLLES'S FRACTURE—DORSAL VIEW.
a. Prominence caused by the head of the ulna.

fingers gently along the posterior surface of the lower end of the radius, the shelf formed by the displaced upper end of the lower fragment, will usually be felt. Also the prominences and depressions about the wrist, the flexion of the fingers, and prominence of the head of the ulna, and, above all, the position of the styloid processes—in health, the styloid process of the radius

is on a lower level than that of the ulna, but in fracture the position is reversed, the ulnar being on a level with, or below, the radial. Another symptom of some importance, is the obliteration of the natural hollow on the front of the lower end of the radius, its place being taken by a prominence.

Treatment.—The bone, in ordinary cases, is placed in position by extension, counter-extension, and manipu-

Fig. 32.



ANTERIOR SPLINT FOR COLLES'S FRACTURE.

1. The gap for the muscles of the thumb, and to allow the lower fragment to be pushed forward. 2. That part of the splint that runs along the front of the ulna, and extends as far as the centre of the palm; the splint is sometimes used without this part. A. B. This line must not come further down than the lower end of the *upper* fragment.)

lation; in difficult cases it may be necessary to employ forcible and full flexion before it is replaced. Two splints (GOOCH) are required—the anterior one (Fig. 32) must not extend further than the centre of the palm, so that the fingers may be freely flexed from the very first; on its radial side a large piece must be cut out for the prominence of the muscles of the thumb, and also extending upwards as far as the lower end of the upper

fragment (some Surgeons only bring the anterior splint as far as the lower end of the upper fragment). This gap is to allow the lower fragment to be pushed forwards, in order that the natural hollow of the radius may be reproduced when the bones have united. The posterior splint extends to the knuckles. Both splints are to be well padded and applied; but a specially thick pad must be placed under the posterior splint opposite the lower end of the radius, in order to push the lower fragment well forward towards the palmar surface into the gap in the anterior splint. The splints are then to be fastened on by bandages, *secundum artem*, and the arm slung midway between pronation and supination. On account of the large number of tendons around this fracture it is most important to begin passive movement very early, especially in old persons. The fingers and thumb are left free, and moved regularly from the very first, and at the end of the fourth or fifth day the splints are to be taken off, and the Surgeon, placing his index and middle finger over the upper end of the lower fragment, and his thumb on the lower end of the upper fragment, keeps the bones in position, while he gently moves the wrist with his other hand. This must be done every second day till the bones have united—at the end of three or four weeks. There is little or no danger of non-union, as the fracture is through the cancellous tissue, but there is *great* danger of a stiff and useless wrist resulting, especially in old persons, which is a great inconvenience to the old lady, and a silent witness against the Surgeon. There are many other forms of splints used, but the results of the above simple method, that generally adopted in Edinburgh, are so satisfactory that it is quite

unnecessary to seek refuge in more complicated, expensive, uncomfortable, and less efficient apparatus. Among them may be mentioned the 'pistol' shaped splint, Gordon's splint, Carr's splint, &c. One objection, it seems to me, to most of these special splints, is that the hand is *displaced* as far in the opposite direction by the splint, as that caused by the force that broke the bone in the other direction. That the wrist is extended and the hand displaced to the radial side, is no reason, surely, why it should be unduly flexed and turned as far to the ulnar side—unless, indeed, it be to test the truth of the parallelogram of forces; but in this case it is scarcely necessary to point out that the two forces must act *simultaneously* on the point in question.

CHAPTER XXIV.

FRACTURES—THE LOWER EXTREMITY.

THE PELVIS.

The pelvis may be broken by crushes between a cart and a wall, mining accidents, in railway collisions, &c. (*a*) The **False Pelvis** is usually broken by lateral crushes: but fracture of this part is not so serious as fracture of the true pelvis. (*b*) **True Pelvis**—This is most likely to suffer from antero-posterior compression; the great danger of this fracture is injury to the various pelvic viscera, especially the bladder, urethra, or rectum. The membranous part of the urethra is most apt to be injured, as the fracture often passes through the rami of the pubes and ischium, and is therefore very near the urethra. To detect fracture of the false pelvis grasp and try to move the iliac crests; for the true pelvis feels the rami of the pubes and ischium, but in every case it will be wise not to make a too exact diagnosis, lest sharp spicula of bone be pushed into the urethra or bladder.

Treatment.—The chief point in the treatment of the case is **never to let the patient attempt to pass water,** but the Surgeon should at once try to pass a catheter into the bladder—gum-elastic if possible. If the urethra is ruptured the patient would simply make water into his perinæal tissues on any attempt at micturition,

unless fortunately the centres for that act were paralysed by the shock. If, when the catheter is passed, clear urine is drawn off it shows that the bladder is not ruptured. Should the urine be bloody it may point to various accidents, but at any rate in all cases of doubt a soft catheter should be tied in and a syphon arrangement attached to it so that the urine may drain away as soon as it enters the bladder. The pelvis is then to be steadied by a broad flannel bandage with plenty of wadding below and a double spica over all. The prognosis is fairly good so far as immediate danger to life is concerned, *but* ever afterwards the patient will be the subject of the worst possible form of organic stricture—the traumatic—with all its secondary risks to the genito-urinary organs situated behind the stricture.

THE FEMUR.

This bone is developed from five centres, that for the shaft appearing soon after the centre for the clavicle. At the upper end there are three centres—one for the head, which appears at the end of the first year; another for the great trochanter, which appears during the fourth year; and a third for the lesser trochanter, which appears between the thirteenth and fourteenth years. All the three join the shaft about eighteen. There is only one centre for the lower end of the bone, and that appears *two weeks* before birth and joins the shaft at twenty years of age. It will be noticed, therefore, that, as usual, the order of union of the centres is the reverse of their appearance.

In the *adult* the neck of the femur forms an angle of 125° with the shaft: in *children* the angle is even

more oblique; and in *old age* the neck drops nearly to a right angle with the shaft, and not only so but its cancellous tissue undergoes fatty degeneration and interstitial absorption, and its compact shell is also thinned. The femur is thickly covered by muscle throughout its entire extent; it is perhaps least thickly covered on the anterior aspect of its lower third.

Fractures of the Neck.—These may be—(*a*) Intra-capsular, (*b*) extra-capsular. The following table will assist the diagnosis between intra- and extra-capsular fractures of the neck of the femur—(From Erichsen)—

Intra-capsular.	*Extra-capsular.*
1. Cause—generally slight and indirect, such as catching the foot in the carpet or slipping off the curb stone.	1. Cause—usually severe and direct violence, such as falling from a height or blow on the hip.
2. Force—usually applied longitudinally or obliquely.	2. Force—usually applied transversely.
3. Age—rarely below fifty, most commonly in feeble, aged persons.	3. Age—usually below fifty, chiefly in vigorous adults.
4. Pain and constitutional disturbance slight.	4. Pain and constitutional disturbance usually considerable.
5. No apparent injury to soft parts about the hip.	5. Considerable extravasation, ecchymosis and signs of direct injury to hip.
6. Crepitus often obscure.	6. Crepitus (when not impacted) very readily felt.
7. Shortening usually at first not more than one inch.	7. Shortening (when not impacted) at least two inches or more.

There is usually marked *eversion* in both cases, partly perhaps because this is the natural position of the limb, but chiefly from the action of the psoas and iliacus muscles, the adductors, the glutei and other external rotators of the hip joint. The shortening of the limb is caused by the glutei muscles, rectus femoris, and ham-string muscles (biceps, semi-tendinosus, and semi-membranosus). The cause of eversion in impacted extra-capsular fracture is probably due, as BIGELOW has pointed out, to the thinness and less resisting nature of the compact shell of bone on the posterior surface of the neck of the femur, as compared with the anterior. It therefore yields more readily, 'crushes up and becomes impacted.'

Intra-Capsular may be either impacted or non-impacted. In impacted the lower fragment is driven into the upper. The **predisposing cause** is the changes already mentioned as occurring in the direction and internal structure of the neck of the femur; the **exciting cause**, some very slight *indirect* violence, as tripping on a stone, turning in bed, &c., and, as a result of the snapping of the neck of the bone, the patient drops down. It is specially apt to occur in women beyond a certain age. In some cases, probably, from the nature of the cause, the fracture is at first sub-periosteal, so that at first there would be little or no shortening, as the fragments are held in position by the periosteum, and the cervical reflection of the capsular ligament: but later, these structures soften and yield, either from the movements of the limb, or from inflammatory softening, as will also the capsular ligament itself, which is not, in the first instance, torn. These facts explain the slow appearance of the shortening so often noticed in intra-

capsular fracture, and which is apt to mislead the incautious Surgeon; or, again, the sudden increase of shortening under manipulation. The limb lies helpless, extended and everted, but can be moved freely by the Surgeon in all directions, probably with the production of crepitus. The great trochanter is raised as shown by BRYANT's test, or a still simpler and more effective one used by Professor CHIENE, viz:—to mark with ink the anterior superior spines of the two sides, and also the tops of the great trochanters of the two sides, and then putting two straight pieces of 'Gooch,' or a narrow board, transversely on these four points, one can see at a glance whether the edges of the two pieces are parallel. This plan can be used with the greatest freedom by any-one and anywhere, and absolutely without disturbing the patient in the least. On rotating the foot it will be noticed that the trochanter rotates round a smaller circle than the trochanter of the sound side. As the patient stands the knee is flexed somewhat and the heel raised. In the usual state of the parts in health blood is brought to the head of the bone by the ligamentum teres, synovial membrane surrounding it, the thick periosteum and the cervical reflection of the capsular ligament. In unimpacted fracture of the usual kind all these sources, save the ligamentum teres, and, perhaps, the synovial membrane, are cut off: for this reason it is said, and, perhaps, also because the parts are not kept in proper apposition, the union is usually by fibrous tissue only. In those that heal by *bone* it is presumed that the fracture has probably been impacted, or sub-periosteal, or not strictly intra-capsular.

Extra-Capsular Fracture is usually impacted, but may also be unimpacted. In the impacted variety the

upper fragment is driven into the great trochanter, splitting it up and increasing its breadth. It is equally common in both sexes, and most often met with during vigorous adult life from a severe direct blow to the outer side of the hip, but in older persons may result from a simple fall on the great trochanter. In the non-impacted form there is distinct crepitus, severe pain on attempts at movement, and great shortening. In the impacted form there is great pain, but the patient may possess a considerable amount of power over the limb, eversion, slight shortening, usually about three-quarters of an inch only, and another very characteristic sign, viz., broadening of the great trochanter in the antero-posterior direction (CHIENE). Hence, given a case where the patient has had a fall on the hip, slight eversion, three-quarters of an inch of shortening and broadening of the great trochanter, there can be no doubt as to what has taken place—impacted extra-capsular fracture. These simple tests further avoid all disturbance of the limb, save the patient from needless pain, and escapes the risk of making the impacted fracture unimpacted. If further confirmatory evidence is wanted then we can use the previous simple test for the position of the great trochanter.

In addition, of course, to these tests others may be used, as BRYANT'S, NÉLATON'S, and MORRIS'S: BRYANT'S line will be shortened from half to an inch, and the trochanter is nearer the middle line, as shown by MORRIS'S test. In fractures of the neck the ilio-tibial band is also relaxed (ALLIS).

DIAGNOSIS AND TREATMENT.

Fractures of the neck must be distinguished (1) from

the **backward dislocations.** In dislocation we have marked *inversion* (except in the rare form of the everted dorsal) the *rigidity* of the limb in certain directions, the *absence of resistance* when the fingers are pressed into the upper part of SCARPA'S triangle, the presence of the head of the bone in an abnormal position, and other signs of dislocation. Sometimes, however, there is inversion in fracture of the neck, some say due to muscular action—the adductors, because the external rotators are torn off or paralysed by the injury, but is more likely due to impaction in that special position from the position of the limb at the time of the injury, or from the direction of the force. But in any case there will be the usual feeling of resistance in the groin, as the head of the bone is in its proper place, the Surgeon will be able to obtain passive movement in all directions quite freely, and there will probably be broadening of the great trochanter. It must also be distinguished (2) from the condition of the hip met with in **chronic rheumatic arthritis,** where the appearance resembles closely that met with in fracture; but in this condition there is no history of injury to account for it, though, of course, a person suffering from chronic rheumatic arthritis may also be the subject of fracture of the neck of the femur, when the diagnosis becomes very difficult. The Surgeon must also be on his guard, and warn those who have received a fall or blow on the hip of the probable result, viz., a shortening of the limb taking place in the course of a few weeks, more especially in old persons, otherwise he may be unjustly blamed for having overlooked a fracture of the neck of the femur. It is a curious fact that (3) **interstitial absorption of the neck**

of the bone often follows blows on the hip, coming to resemble, after some weeks or months, a fracture of the neck. But in this case there will be no broadening of the great trochanter; the shortening does not take place at the time of the accident, but after the lapse of some weeks, and comes on gradually. In *any* injury of the hip therefore in the aged, give a guarded prognosis, and tell them the possible, and even probable, result.

Treatment of Fractures of the Neck.—In *all* cases treat as if we meant to get bony union. The old plan was simply to keep the patient a week or two in bed, then allow them to rise and hobble to the end of life (often not far distant,) with the aid of a friendly stick or crutch, as best they could. Many Surgeons seem to think that this is still the best method of treatment, with the addition perhaps of a well-fitted THOMAS's hip splint. Formerly the mortality from this accident was greater than that of amputation at the hip joint, the causes of death being failure of the general health, hypostatic congestion of the lungs, and bed sores; these, combined with imperfect nursing, very quickly finished the patient. But, in Edinburgh at least, all this is altered—with good nursing, special care being taken to keep the buttocks and back *clean and dry*, the use of the weight and pulley, with a single or double long side splint to prevent eversion, the former dreaded and fatal dangers are practically unknown.

In **impacted** fracture, provided the shortening and eversion are not greater than usual, all that is required is simply to steady the limb by a double long splint, without any extension apparatus at all. The bone must on no account be unimpacted, as it is in the very best possible condition for bony union. For the method of

putting up the limb by the long splint, or weight and pulley, in fractures of the neck, see end of Fractures of the Femur.

Fig. 33.

FRACTURE JUST BELOW THE LESSER TROCHANTER.

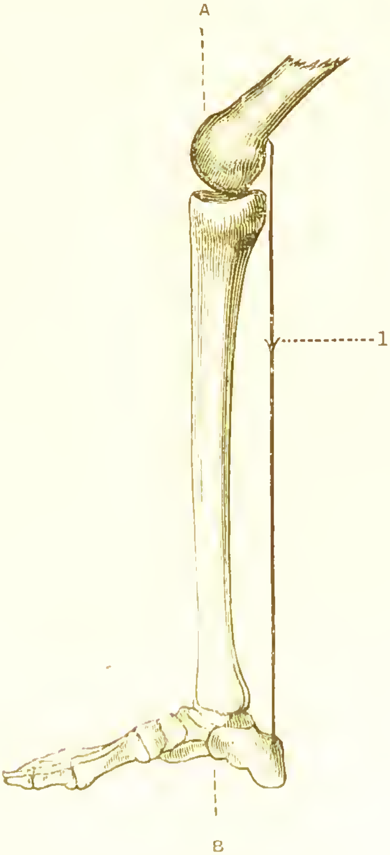
1. To represent the action of the psoas and iliacus.
2. Muscles acting on the lower end of the bone—gastrocnemius, plantaris, and popliteus.

FRACTURES OF THE SHAFT.

Fracture of the shaft is very common in children: excluding fractures of the neck, one-third of all fractures of the femur occur in children under ten. If the fracture be through the **upper** part of the shaft, **below the lesser trochanter,** the upper fragment is tilted forwards and everted by the psoas and iliacus, and drawn outwards by the external rotators and glutei muscles (Fig. 33); the lower fragment is drawn upwards by the rectus femoris in front, and the hamstring muscles behind, and drawn inwards by the pectineus and adductor muscles. Hence there is marked shortening, eversion, and crepitus. In fracture through the **middle** of the shaft, the lower fragment is drawn inwards and upwards behind the upper fragment by the adductor fibres attached to it, and rotated outwards; while the upper fragment projects forwards, usually from the same causes as in fracture of the upper part of the shaft. In fracture in the **vicinity of the condyles** the lower fragment is tilted backwards by the gastrocnemius, plantaris, and popliteus muscles, and can be felt deep in the popliteal space (Fig. 34): the upper fragment is drawn inwards by the pectineus and adductors, and tilted forwards by the psoas and iliacus. In all cases of oblique fracture of the shaft of the femur there is shortening and external rotation—shortening being caused by the contraction of the flexors, extensors, and adductors of the limb, while external rotation is caused by the external rotators being more powerful than the internal. In children fractures of the shaft of the femur are frequently transverse, and, in such cases, the well-marked displacement is absent: and, in con-

nection with fractures in the vicinity of the condyles in children, it should be borne in mind that diastasis of the condyloid end of the femur may take place—the

Fig. 34.



FRACTURE NEAR THE KNEE JOINT.

1. To represent the action of the gastrocnemius, &c., in tilting the lower fragment backwards, into the popliteal space. A B. Axis of the unbroken bone.

lower epiphysis of this bone not uniting with the shaft till the twentieth year.

METHODS OF TREATING FRACTURES AT ANY PART OF THE FEMUR.—1. **The Long Splint.**—I begin with the 'long splint,' usually named after Liston, not because it is the best method, but because it will be more convenient to describe it first, as the same apparatus may be used, but for a very different purpose, along with the weight and pulley, and doing so will therefore save repetition. In some cases too it may be impossible to use the weight and pulley, *e.g.*, in cases where patients are cooped up in the time-honoured, but sadly defective (for the purposes of the Surgeon, and from a hygienic point of view as well) 'box-bed.' For the long splint we require a board four or five inches broad, long enough to reach from the axilla to six inches beyond the foot; through its upper end are two holes, and its lower end is cut into a three-pronged like fork. This is rolled up in a sheet so folded that it will reach from the tuber ischii to the malleoli, thus leaving the last six inches of the splint bare; enough of the sheet must be left free to surround both limb and splint afterwards. The splint is then laid along the injured side with the free part of the sheet under the limb. The 'perineal band' is next placed in position, but left slack; this consists of a padded handkerchief, or one covered with gutta-percha, passing under the perinæum and tied through the holes in the upper end of the splint. The foot should now be fixed to the lower end of the splint by passing a padded handkerchief in a figure-of-eight round the ankle and foot twisting the ends round each other in front of the sole, and then tying them to the horns of the splint; the objection to this plan is that it is apt to cause pressure on the instep or ankle, and causes eversion of the foot, as the pull is

oblique—this last might be remedied by fastening a little square of wood to the splint in front of the sole round which the handkerchief could be brought. To avoid these defects the late Professor SPENCE used plasters applied to the limb as in the weight and pulley method, and attached to a square foot piece, and then the foot piece fastened to the horns of the splint. Thick pads are then to be placed along the side, and 'bird nest' pads applied over all prominent points, as the hip and knee. Then bring the free end of the sheet round over the limb, and fasten tightly to the folds of sheet round the splint, by means of long pins, thrust vertically across the line of the splint. The upper end of the splint is now to be fastened to the trunk by means of a broad flannel bandage, or kitchen roller, folded once or twice. The foot having been already secured to the horns of the splint, finally make extension by *pulling on the perineal band* and fastening it to the two holes in the upper end of the splint. This is the most important part of the whole apparatus; by pulling on the perineal band the splint is forced downwards and with it the leg, as the foot is firmly fastened to the splint. On the other hand, should we try to extend by tightening the handkerchief or tapes at the foot, the splint is forced upwards, and with it the lower fragment of the femur. It is very tempting, indeed, to have a pull at the handkerchief at the foot, and as a rule nine students out of every ten tell you that this is how the limb is to be lengthened. The above is all that is required in fracture of the necks of the femur. But in **fractures of the shaft** we require in addition padded GOOCH splints; in fractures of the *upper* and *lower* parts of the shaft the splints must be

antero-posterior, in fractures through the middle part of the bone the splints should be lateral. The splints are fastened by slip knots, which must be be tied over the *inner side* or *front* of the thigh; because if tied on the outer side they could not be tightened or loosened without undoing the whole apparatus.

2. **By Weight and Pulley.**—For this purpose we require two isosceles triangles of strong sticking plaster with the selvage removed, each long enough to reach from the malleoli to below the seat of the fracture, or to the middle of the thigh in fractures of the upper part of the femur, or in hip joint disease. The bases are split into three tails, and strong pieces of tape are stitched to the apices. The first thing to be done is to pad the heel and the malleoli well and bandage the foot and ankle by figures-of-eight in the usual manner, covering the malleoli well. Now apply the plasters, bandaging the leg and thigh over them, placing plenty of padding around the knee; this is to be continued till the base of the plasters is almost reached, when all or one (the centre) of the tails must be turned down over the bandage and then the bandage continued upwards, and downwards again as far as may be deemed necessary. The tapes at the apices of the plasters are next passed through buckles attached to the sides of a square piece of wood, slightly broader than the sole of the foot. Through the hole in the centre of this piece pass the end of the cord that supports the weight and secure it there either by simply knotting it, or by a little bar of wood. The pole bearing the pulley is then to be fastened to the end of the bed in some way so as to project from it at an acute angle. Raise the lower end of the bed and place two high blocks under its feet;

this transforms it into an inclined plane, and a part of the weight of the patient's body acts as the counter-extending force, and obviates the necessity for the irksome perinæal band. The weight is now attached to the cord, and the cord placed over the pulley, and the extension is completed. A sand bag is to be placed on each side of the limb to prevent eversion, and the whole protected by a wire cage.

The sand bags, however, are troublesome, and the long splint is now generally used instead, with some special foot-piece to prevent it from tilting. In every case Professor CHIENE uses a *double* long splint for the same purpose, with the most satisfactory results. The patient can absolutely move nothing except his head and his arms; this of course gives the fracture the very best possible chance to unite. The splints may be fastened to the limb by ordinary roller bandages, or a sheet may be used. The limb must be kept in this position for six or eight weeks, and after that encased in a starch, or plaster of Paris, bandage. The patient may then be allowed to go about on crutches, either with the injured limb slung to the neck, or else the sole of the sound foot raised so that the injured limb may hang free.

FOR CHILDREN.—1. **The Double Long Splint** may be used, connected at the bottom by a transverse bar; this is necessary because of the restlessness of the patient. The two splints should be wider apart at their lower ends, and not parallel with each other, for the use of the bed pan.

2. BRYANT'S method of **Vertical Suspension** of the broken limb. A posterior splint is applied from the heel to the nates, and short splints on the sides and

front of the thigh, strapping having been previously attached to the leg for the purposes of extension. The limb is then slung up to a hook in the ceiling, or some other convenient point, so as to keep the limb at right angles to the body. By this means the bandages are kept clean, and the weight of the body acts as a constant counter-extending force.

MacIntyre's Splint as Modified by Liston.—Although the great majority of fractures of the femur are best treated in the straight position of the limb, in some *rare* casesit has been found that the fragments could only be kept in position by flexing the leg and thigh. This method is advised in cases of transverse fracture immediately above the condyles, where the upper end of the lower fragment is tilted directly backwards by the gastrocnemius, plantaris, and popliteus muscles, hence, when the leg is fixed up in the extended position, the knee joint is really flexed, and the result is either non-union or union in a useless position. It is for cases such as this that BRYANT recommends division of the tendo Achillis before putting the limb up in the straight position, in cases where the double inclined plane fails to remove the deformity. The splint used for this purpose is MacIntyre's splint as modified by Liston. I have seen the splint twice—once in the lumber room of the hospital, and again in the examination room. It is from this latter fact that I subjoin a short description of the splint and its mode of application. It has also been used in cases where, in the straight position, the sharp end of the bone threatens to come through the skin. In this splint the weight of the body acts as the counter-extending power. The splint, then is a double inclined plane

with a moveable joint at the knee, and a foot piece; the foot piece is fixed in a slit, so that it may be drawn forwards if desired, and its angle to the axis of the splint can be shifted by means of a screw. The angle at the knee can be altered in like manner. At the lower end there is a piece cut away, opposite the heel and tendo Achillis, to prevent undue pressure.

In applying this splint, the first thing to be done is to fasten a strip of bandage across the space at the heel to prevent it falling too far backward through the gap. The splint must now be very well padded, so that the limb may rest *on* rather than *in* it; but the foot-piece must be padded separately. The limb is now laid on the splint, and the foot fixed to the foot-piece by a handkerchief passed behind the splint at the heel, then, making a figure-of-eight round the ankle and foot, the ends being fastened to a button on the sole of the foot-piece. The foot-piece is then to be screwed to a right angle, and the limb fastened to the splint by interrupted circles of bandage or plaster. Screw the knee into such a position that the fractured ends are in apposition—in fracture at the lower end of the femur this will be nearly a right angle. Cover up the screw behind the knee joint, lest the patient middle with it, and swing the limb splint and all, or else fasten the part behind the heel firmly to a block, so as to get the required height, and also for the purpose of steadying the splint. This splint is also used by some in fracture of the bones of the leg.

THE PATELLA.

This is merely a sesamoid bone developed in the tendon of the quadriceps extensor. It has one centre

which appears about the second year, and is fully ossified about puberty. It may be broken by *direct* violence when the knee is flexed, and the fracture may then be comminuted, transverse, vertical, stellate, &c. The usual cause of fracture, however, is muscular action, as when the patient slips backwards, and, to save himself from falling, throws the quadriceps suddenly into action, when the patella snaps in the same way that a stick is broken across the knee; the patient falls down *because* the patella is broken, it is not the fall that breaks it. The fracture resulting from muscular action is always transverse, and in all probability *always* into the knee joint; for this reason the joint swells up from the effusion of blood into it, which, however, usually subsides after a few day's rest. When due to direct violence, bony union, it is said, is common enough, but when due to muscular action, the fragments are often widely separated, and the union is usually by fibrous tissue only.

Treatment.—At first in almost all cases, as there is severe inflammation and great effusion into the joint, rest in the easiest position, and evaporating lotions are indicated, or removal of the fluid by antiseptic aspiration. Whatever method of treatment is adopted the patient must be semi-recumbent in all cases, with the foot raised to relax the muscles that displace the upper fragment—the quadriceps extensor, but especially that part of it formed of the rectus femoris; after this the fragment may be brought down by some special appliance. As the upper fragment is alone displaced, the special treatment should be brought to bear on it alone without any circular constriction of the joint. Whatever plan be adopted it must be kept up for six or eight weeks at

least, and after that the limb may be encased in plaster of Paris, or else the patient must constantly wear a posterior straight leather splint, so as to prevent the joint from being bent for at least three months. Many Surgeons believe that the best results are obtained by cutting down on the patella by a vertical incision, and pulling the fragments together by wire or catgut. The objection to this plan is that it opens into the knee joint.

1. **By Posterior Inclined Plane.**—This is a straight wooden splint with or without a foot-piece, with notches or hooks opposite the knee joint to give a fixed point from which to pull on the patella. The splint is well padded, its lower end well raised, and then the limb placed upon it and bandaged to it from the foot upwards. When the knee is reached take two or three figures-of-eight from the notches on the side of the splint above and below the patella, gradually pressing the fragments together. If there is much swelling and effusion into the joint do not forcibly drag the broken parts together, but first wait till the effusion has subsided. The thigh is then bandaged to the splint, and lastly the foot raised and swung. It will probably be found more convenient to fix the leg and thigh to the splint first and then to use a separate bandage at the knee joint, as this can then be tightened from time to time without disturbing the rest of the splint. The objection to this plan is that the vessels supplying the fractured patella are compressed and the fragments starved.

2. **By Malgaigne's Hooks.**—Two pairs of steel hooks, of which the pair next the skin work in a slot in the other pair, and which can be screwed together or

loosened by a screw and nut arrangement, worked by means of a handle. They may be used as MALGAIGNE himself used them, simply passing them through the skin into the broken fragments, only with strict antiseptic precautions; or they may be used in the way practised by the late Professor SPENCE. Two large pieces of stout plaster, each seven inches long by five broad, with a semi-circular piece cut out of the upper and lower ends respectively, are prepared; also a number of smaller rectangular pieces three inches by two. The posterior inclined plane is applied as before described, and the leg and thigh bandaged to it. Then stretch the skin and apply the long pieces of plaster so that the notches fit round the edges of the patella; the smaller pieces are next fastened on to the front of these. The points of the hooks are then stuck into these smaller pieces and screwed to the required tightness. In this plan there is no circular constriction of the limb; it was spoken of very highy by the late Professor SPENCE.

3. **Manning's Splint.**—This splint acts on the upper fragment of the fractured patella by elastic, and therefore constant traction, and at the same time avoids circular constriction of the limb, so that the articular arteries are not compressed. It consists of a wooden back piece, a little wider than the knee joint, and long enough to reach from the sole of the foot to the gluteal fold, and provided at the lower end with a foot-piece. At the junction of the middle and lower thirds is a transverse oblique slit one and a half inches long. Strips of strong plaster, two inches broad, and long enough to encircle the thigh, and overlap by some inches are attached to a calico band. The free end of this band is carried through the slit, and the strips of plaster

are open on the upper part of the splint. A piece of wood is attached to the lower part of the splint, and another piece of corresponding size is attached to a loop at the end of the calico band, so that, when drawn down and the splint adjusted, these pieces may be five or six inches apart.

The foot and the leg having been previously bandaged as far as the lower edge of the patella, and the splint padded so as to leave the slit uncovered, the strapping is heated by means of a bottle of hot water, and, while an assistant draws down the upper fragment by grasping the muscles of the thigh, the strips of plaster are carried firmly round the limb from above downwards, extending from just below the gluteal fold to within three inches of the upper border of the patella. It being important that the band of calico should be kept in the middle line, the upper part of the thigh is then secured to the splint by a few turns of a roller. Lastly, elastic rings are passed over the projecting ends of the pieces of wood, on each side of the splint, so as to exercise sufficient traction on the muscles pulling on the upper fragment and approximate the fragments. In the drawing given in ERICHSEN'S *Surgery*, the limb appears to be lying flat; if this is the case a better plan, we think, would be the usual position for fractured patella—the heel raised some distance above the level of the buttocks.

4. The plan adopted at the Middlesex Hospital seems to be a good one. A broad piece of plaster cut out at one border somewhat horse-shoe shaped, but with the ends of the curve prolonged, is fixed to the thigh, so that the curved edge is level with the normal position of the patella, and is fixed by a few turns of a roller

bandage. The limb is now placed on the posterior inclined plane, with foot-piece, or a MacIntyre's splint. The lower fragment is fixed by means of a pad of lint and plaster bandage. To the ends of the plaster, tapes are stitched, which are attached to indiarubber 'accumulators,' which are in turn fastened by means of strips of bandage to the footboard of the splint. The requisite amount of tension is obtained by loosening or tightening these strips of bandage.

THE BONES OF THE LEG.

Like the bones of the forearm, both these bones are developed from three centres, that for the shafts appearing about the usual time. The centre for the head of the tibia appears at the time of birth, and that for the fibula about the fourth year; both join their respective shafts at twenty-five. The centres for the lower ends of both appear during the second year, and join the shaft at twenty. It will be noticed, therefore, that, opposite to the usual custom, the lower epiphysis of the fibula appears first and unites first.

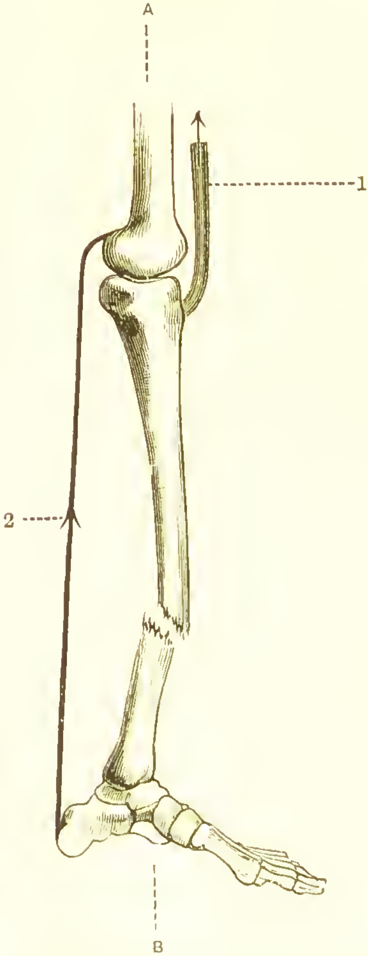
The fibula is surrounded by a thick pad of muscles for the greater part of its extent, its lower fourth, however, being subcutaneous. The anterior border and inner surface of the tibia are entirely subcutaneous, hence any irregularity in outline can be readily detected, and for the same reason the fracture is often compound, either from the force that breaks the bone in *direct* violence, or else from a sharp fragment being forced through the skin in *indirect* violence. Each of the bones may be broken separately, but usually both are broken together. If the tibia alone be broken, or if the fibula alone be broken, there is usually little

displacement because the sound bone acts as a splint to the fractured one. The weakest part of the shaft of the tibia is about its lower third, and the weakest part of the shaft of the fibula is about its upper fourth, and at these points, therefore, the bones are most likely to give way in fracture from *indirect* violence. In *direct* violence the fracture will be transverse and at the point struck. In *transverse* fractures of one bone there will be little displacement, muscular action simply keeping the fractured ends in apposition; if, however, the fracture be oblique and both bones broken, the lower fragment is drawn upwards and backwards by the muscles of the calf (gastrocnemius, plantaris, and soleus), and this is more marked if the fracture be situated at the lower part of the shafts of the tibia and fibula (Fig. 35): while the upper fragment is tilted forwards by the *tendo patellæ* (the tendon of insertion of the quadriceps extensor cruris—rectus, the two vasti and crureus)—and rotated inwards by the sartorius, gracilis, and semi-tendinosus, and this displacement of the upper fragment is more evident if the fracture be at the upper part of the shaft of the tibia. All fractures of the bones of the leg occur with extreme rarity in infancy and childhood.

Tibia Alone.—This is usually the result of direct violence, as a kick or a blow. In transverse fracture, when the fibula is intact, the fracture may be missed unless great care be exercised, as there is no displacement and the patient may be able to walk wonderfully well. But the existence of a *tender spot* at the seat of the crack, and the fact that firm *indirect* pressure on the bone above and below this point, will probably produce a yielding and crepitus, and certainly cause

pain at the seat of the fracture, should prevent any mistake in the diagnosis.

Fig. 35.



FRACTURE AT LOWER PART OF LEG.

1. Muscles forming the ligamentum patella, displacing the upper fragment forwards. 2. Muscles of the calf dragging the heel backwards. A. B. Axis of the unbroken bones.

Fibula Alone.—This bone may be broken either by direct or indirect violence. The usual seat is from two to five inches above the malleolus, especially if caused by indirect violence. It may be caused by a twist of the foot either outwards or inwards, and is then very often associated with partial or complete dislocation of the ankle joint; but in that due to inversion of the foot there is often no displacement at all. If due to eversion, the broken ends of the fibula are driven inwards towards the tibia (see Dislocations of the Ankle —'Pott's Fracture'). There is also a fracture of the fibula occasionally met with through, or just above the malleolus, caused by direct violence, where there is also an absence of displacement. Here, again, in diagnosing such fractures, the great guides must be the existence of a tender spot, sharply defined (differing therefore from a bruise or sprain, though both may be present), and the indirect method of pressure applied to the upper part of the fibula, pressing it towards the tibia, when pain will be caused at the fractured spot. If it be merely a bruise there will be no pain as thus tested.

Both Bones.—This fracture may be caused by direct violence, as kicks, blows, wheels passing over, &c., when the bones give at the point struck; or indirect violence, such as jumping from a height, severe twists, &c., when the bones yield at their weakest parts. The limb is usually everted from the weight of the limb, from the force breaking the bones, and probably also from muscular action.

Treatment.—In cases of fracture of the shaft of a single bone, with little or no displacement, any simple apparatus will be sufficient, such as Cline's side splints for the first few days, till the swelling has subsided,

when the limb may be encased in a starched bandage, the Bavarian plaster splint, Croft's dressing, or it may be treated by the 'Edinburgh box splint' (SPENCE'S), to be afterwards described. The chief objection to all immovable dressings is that the fracture cannot be examined from time to time to correct any possible error of position. When **both bones** are fractured, or, indeed, in any form of fracture, the most convenient splint to use, and one by which perfect apposition can be secured, is that known as—

The 'Edinburgh Box Splint.'—This consists (1) of two narrow pieces of board long enough to reach from the knee to a few inches beyond the sole, so that when applied they should command both knee and ankle joints. (2) A sheet folded to a little less in length than the length of the splints. (3) Two small towels to form pads for the front of the limb.

In applying this apparatus roll up the splints from different sides in the sheet till there is just enough room left for the leg. We have thus a 'box,' the sides of which are formed by the splints covered with the sheet, the posterior part of the box simply consisting of several layers of the folded sheet. If desired this may be rendered rigid by introducing a strip of pasteboard between the layers of the sheet. Now bend the knee, and lay the leg in the box thus made, taking care to pad the prominences about the knee and the malleoli well. If preferred, the leg may be laid on the middle of the sheet in the first instance, and the splints rolled up from either side; this will obviate the necessity of lifting the leg afterwards. The foot is then to be fastened by a few turns of a figure-of-eight round the ankle and splint; then lay the towel pads on the front, so as to

overlap at the fractured part, after which secure the splint to the leg by slip knots. By this plan the fractured point can be examined very easily without disturbing the rest of the splint, which could not be done were an ordinary roller bandage used. The limb is now to be laid on a couple of pillows, or swung, with the knee considerably bent, to relax the muscles of the calf. The fracture can be examined from time to time without disturbing the limb. The most important points to be kept in mind are (1) to keep the foot at right angles to the leg; (2) to guard specially against any eversion of the foot, a little inversion is not so objectionable, although this too is to be avoided. Both these conditions can be readily carried out by using the 'box splint.' To keep the foot at right angles a figure-of-eight of elastic, or ordinary domet bandage, is passed round the foot and fastened to the sides of the box. To judge whether the foot is properly placed as regards eversion and inversion, it should be noted that when the foot is in the proper position *the ball of the great toe, the internal malleolus, and the inner edge of the patella are all in one vertical plane.* Even in health, however, there is a slight tendency to inversion of the foot. In methods of treating these fractures where the knee joint is flexed, and the leg laid on its outer side on a pillow, it is impossible to judge of the eversion and inversion; hence the usual result is that the patient rises with the foot very much everted, and, to that extent, a crippled foot. A condition not only bad at the time, but is likely to induce disagreeable, secondary consequences, *e.g.*, flat foot. In cases where the fracture is very oblique, and accompanied with much shortening, it *may* be necessary to employ the

weight and pulley. In these cases there may not be sufficient room to apply the extension plasters, but a short elastic sock, laced to the foot should be used, with side straps to fasten to the buckles on the square of wood to which the cord is attached. The 'box splint' may be used in almost *every* case of fracture of the bones of the leg, even for fracture low down where the chief difficulties are, the eversion of the foot and the drawing back of the heel (Fig. 35), although special splints have been devised for both these displacements — DUPUYTREN'S splint for the eversion, *e.g.*, in 'Pott's fracture;' and the 'stirrup splint' (SYME), for the falling back of the heel.

Dupuytren's Splint. — This may occasionally be useful, although I have never seen it used in 'Pott's,' or any other fracture. It is a most troublesome splint to apply properly, and equally difficult to keep in proper position when it is applied, as it always tends to shift; if it is to be used the limb should be laid on a pillow and not swung. Further, the same objection may be urged against it as against the special splints used for Colles's fracture; it causes excessive inversion, thus *displacing* the foot as far in the opposite direction as the injury did in the other.

It consists (1) of a tri-furcated wooden splint, with two holes at its upper end, long enough to reach from the *head of the tibia* to four or five inches beyond the sole. (2) A pad of towel or sheet the width of the splint, and doubled on itself at its lower end.

Fasten the split ends of a roller bandage through the holes at its upper end, as this will steady the splint and prevent it from being forced upwards. Apply the pad over the splint, so that the doubled end

of the towel may be over the internal malleolus, forming a soft fulcrum round which the foot is to be inverted; fasten it to the splint by slip knots. As the object is to invert the foot and throw the broken ends of the fibula outwards, the splint thus prepared is applied along the inner side of the limb on the same lie as the bones of the leg, and secured firmly to the head and upper part of the tibia, but not carrying the bandage above the knee joint. The knee must be bent so as to relax the muscles of the calf which pull back the heel and point the toes; the foot is then brought to right angles and inverted. At the lower part of the leg, the bandage securing the splint to the leg and inverting the foot, must not go above the external malleolus, otherwise it will press the broken ends of the fibula towards the tibia. The foot is then to be inverted to the desired extent by means of a few properly applied figure-of-eight turns of a bandage; the figures-of-eight must be led round the inner side and across the dorsum of the foot, and then inwards across the sole, and secured round the prongs of the splint. Lastly, the knee being well flexed, as already indicated, the limb should be laid on its inner side on a pillow, and secured thereto by strips of bandage.

The 'Stirrup Splint' (Syme).—This is a wooden splint with one end like a horse shoe, and two holes through the upper end. A sheet or large towel is also required, rolled up from each side towards the middle, forming a pad very thick at each side but less so in the middle, so that when applied along the front of the sharp edge of tibia, the splint may rest on the rolled up thick parts of the pad, in this way fulfilling two purposes, first steadying the splint, and secondly pro-

tecting the sharp edge of bone from pressure. This pad is also doubled on itself at one end. The splint was formerly used to prevent retraction of the heel in fracture of both bones of the leg low down; it may also be used at the same time to overcome excessive inversion or eversion. Like the last splint it is most difficult to fasten on and keep in position.

Fasten the pad on the splint by slip knots, so that the doubled end is level with the middle of the arch of the horse shoe. Lay the splint along the front of the tibia with the prongs on either side of the foot. Then a handkerchief, or bandage, is placed behind the tip of the heel, neither above nor below that point—if brought in front of the sole it would push the heel backwards, and if applied higher up it would simply cause greater displacement. It is then carried round the shoulders of the prongs, there crossed, and the figure-of-eight completed round splint and ankle. The object is simply to lift up the heel. Lastly, the upper end of the splint is fastened to the leg by a turn of bandage passed through the two holes there, so that the splint may not slip; and a strip of bandage is passed from one horn of the splint to the other in front of the foot.

But as I said before, a properly applied 'box splint' is all that is required in almost every case, whether there be marked eversion or not, with or without displacement of the heel backwards.

Both bones of the leg require about eight weeks to unite firmly; the tibia alone requires seven, and the fibula alone six.

CHAPTER XXV.

EXCISION OF BONES.

THE UPPER JAW.

The upper jaw articulates with nine bones—the frontal, the ethmoid, the nasal, the malar, the lachrymal, the inferior turbinated, the palate, the vomer, and lastly with its fellow of the opposite side. In the case of malignant disease, the bone must only be removed, provided the Surgeon convinces himself that he can remove all the diseased tissue, and, at the same time cut wide of the disease. In examining tumours of the upper jaw, look at it from four points of view—(1) From the face; (2) from the orbit; (3) from the nose; and (4) from the mouth and pharynx. Should it implicate the basi-sphenoid it will be better to leave it alone. As in all operations about the mouth, hæmorrhage is one of the chief difficulties and dangers, not merely from the actual loss of blood, but from the danger of asphyxia from the blood passing into the pharynx; another very serious danger, should it reach the lungs, is that it is apt, at a later period, to set up a suppurative form of pneumonia ('Interlobular Suppurative Pneumonia'—Bell, Wylie), probably from the coagulated blood becoming septic and putrifying in the vesicles. One plan to obviate these risks is to keep the source of the blood lower than the opening of the

larynx, by allowing the patient's head to hang over the end of the table and sponging out the accumulated blood from time to time (ANNANDALE); or Trendelenburg's 'trachea-tampoon' may be used, or some modification of it, or as MACEWEN suggests one may pass a rigid tube through the glottis, after which the entire pharynx is tightly filled with a sponge; or, a still simpler and more efficient plan, adopted by Professor CHIENE, in cases demanding such severe measures—a preliminary tracheotomy is performed, and the pharynx filled with a sponge and a tube, passing from the end of an ordinary funnel, is inserted into the inner part of the tracheotomy tube, and through this the patient inhales the chloroform; over the mouth of the funnel a fold of domet bandage is stretched, and on this the chloroform is dropped as required.

Instruments required.—The usual instruments required in all major operations, and tooth forceps; a narrow saw with a movable back and a large handle; bone forceps; lion forceps; gouges; hair lip needle, or silver wire suture; retractors; chisel and mallet at hand lest they be required; wire nippers; and perchloride of iron, or the actual cautery for the hæmorrhage; solution of zinc chloride, to touch up doubtful parts afterwards; and lastly, some of the special means for the management of the hæmorrhage, and the administration of chloroform. The **Surgeon** stands on the same side as the bone to be removed in the first instance, but during the sawing of the bony points he will probably find it most convenient to stand *always* on the right side. The usual number of **assistants** may be made use of, and their duties require no special mention. (1) Place the **patient** in a semi-recumbent position, shave the parts if

necessary, compress the facial artery as it passes over the lower jaw; extract the central incisor tooth of the diseased side, and then make the incision, (*a*) *Liston's* (Fig. 36). Enter the knife opposite the external angular process of the frontal bone, (*i.e.*, a little above the

Fig. 36.

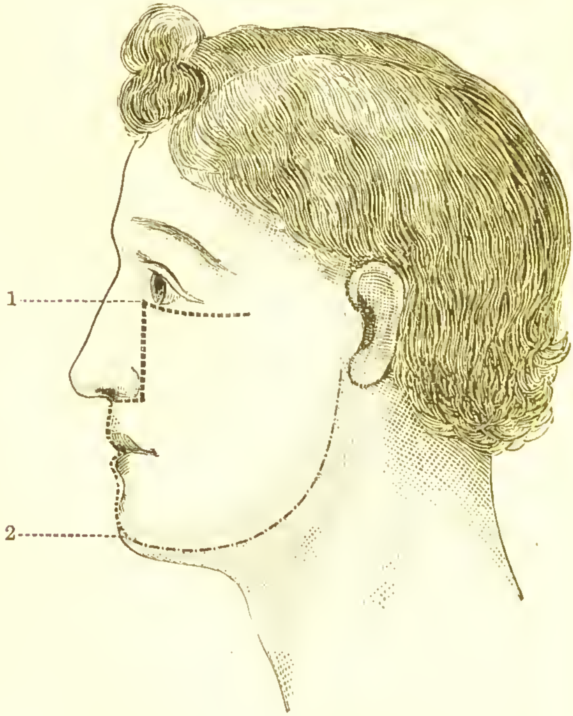
LISTON'S EXCISION O THE UPPER JAW.

A. Position and direction of the additional incision when the malar bone is to be removed as well.

zygoma,) and carry it in a semi-circular manner downwards and forwards to the angle of the mouth. Another incision is then made from the nasal process of the superior maxillary bone down the side of the nose,

round the ala, and through the centre of the upper lip into the mouth; this flap is then dissected upwards and inwards. This is the most convenient incision when the tumour is of large size. (*b*) *By External Flap* (Fig. 37, 1). Cut horizontally from the outer to the inner

Fig. 37.



EXCISION OF THE JAWS.

1. Excision of upper jaw by external flap. 2. Line for excision of the lower jaw.

canthus of the eye, then straight down to the ala of the nose, round it and through the centre of the upper lip into the mouth; this flap is then dissected downwards and outwards. The great advantage of this

incision is that the arteries and nerves of the face are cut close to their terminations, and not through their larger branches, as they are more likely to be by Liston's method. (2) Having divided the mucous membrane and dissected the flap off the jaw, separate the soft parts from the floor of the orbit, including the periosteum, and should the case admit of it, the orbital plate of the superior maxilla as well, using a thin copper spatula to protect them and the globe of the eye. Before going any further it will be well to tie all the bleeding vessels, such as the coronary, after which (3) divide the bony points.

There are four bony attachments to divide; the following order, I think, will be found convenient:—(1) The malar attachment; this is first to be deeply notched with the saw parallel with, and immediately in front of the masseter muscle, passing into the spheno-maxillary fissure. (2) The palate attachment; the saw is passed into the nostril, and the hard palate and the alveolus divided. The saw should be kept parallel in the nostril, as there is but little danger of injuring the soft palate, as it hangs down perpendicularly from the end of the hard palate. It is useless to attempt to dissect off the soft tissues from the hard palate (HEATH). (3) The nasal process of the superior maxilla; the bone forceps alone is usually sufficient for this purpose, one blade being placed in the orbit, the other in the nose, with the *flat* side as usual next the part to be left. If preferred, this process may first be notched with the saw like the other two. Some Surgeons divide these points with the saw in the following order:—palate, nasal, malar, and then complete the division with the bone forceps in the reverse

order. The forceps is now used to completely divide the malar attachment, and, lastly, the palate process and alveolus; in dividing this last part the forceps can also be used as lever to prise the bone from its bed, thus preparing the way for the next part of the operation. (4) Everything being now ready for the gush of blood likely to follow removal of the bone, and the patient brought fully under the influence of the anæsthetic, and the soft palate separated from the hard by a transverse incision, the jaw is firmly grasped with the lion forceps, and with a firm wrench downwards and outwards the bone is torn from its posterior attachments. As the bone is wrenched out any soft tissues must be divided with the fingers or bistoury, such as the origin of the temporal muscle in the zygomatic fossa, and the infra-orbital nerve, &c. When the bone is removed there is great hæmorrhage, and the cavity must be at once packed with a dry antiseptic sponge, or strips of lint till the vessels (which are mostly of small size) have had a little time to close themselves by retraction and contraction. After this the packing is removed and the vessels tied, and some strips of lint, dipped in zinc chloride or Iodoform, introduced to support the cheek flap, and which must be left in for two or three days. Iodoform, or a solution of chloride of zinc, is the most effective antiseptic to use, and afterwards continuous irrigation with some warm antiseptic, *e.g.*, Boracic acid. The incision must be very neatly and carefully stitched up with horsehair sutures; these may be used throughout and will be found very efficient, but when the lip is reached another plan may be adopted—a hair lip needle passed deeply through the tissues of the lip to act as a splint, or a deep silver suture

may be used for the same purpose. *Before* putting in the needle or silver wire, however, a silk suture should be passed through the mucous membrane, but left untied; after this horse hair sutures are passed and tied to hold the skin edge in apposition, then the silver one is tightened, and, lastly, the silk suture through the mucous membrane is tied. In this way neat apposition of the cut edge is insured. If the hair lip needle is used its point must be cut off with the wire nippers. Mr Bell advises that in making the incision through the skin we should make plenty of corners and not rounded curves, as the corners act as guides and enable us to stitch like parts to like, whereas, in curves, it is often difficult to tell exactly the corresponding parts of the two sides.

Should it be necessary to remove the malar bone, then from the end of the upper incision carry another cut, one inch in length, along the zygoma (Fig. 36, A.). In this case also it will be necessary to divide the zygomatic process, and the external orbital angle of the frontal bone into the spheno-maxillary fissure by first using a small saw. and then completing the division with the bone forceps. It is better, if possible, however, to preserve the malar bone, as this leaves the prominence of the cheek.

Chief Parts Cut Through.—(1) *Skin and fascia*, part of orbicularis palpebrarum, orbicularis oris, temporal fascia, part of masseter and temporal muscles, zygomatici, buccinator, and other muscles of expression, nasal duct, levator labii superioris et alæ nasi, compressor naris, depressor alæ nasi, orbicularis oris; mucous membrane of the lip. (2) *Nerves*, chiefly branches of facial and branches of second division of the fifth

that appear on the face, as well as the infratrochlear, and in the end the trunk of the second division of the fifth itself. (3) The various *bony points* already mentioned. In tearing the bone from its posterior attachments the vertical plate of the palate bone, pterygoid fossa and internal pterygoid muscle are usually torn away as well. (4) *Arteries*, (*a*) Branches of the temporal, i. orbital; ii. middle temporal; iii. transverse facial. (*b*) Facial near the angle of the jaw and several of its branches, viz:—i. Superior coronary; ii. lateral nasal; iii. angular. (*c*) Termination of internal maxillary artery, probably, and certainly many of its branches—i. Buccal; ii. posterior dental; iii. infra-orbital; iv. descending palatine; v. spheno-palatine. (5) Corresponding veins.

THE LOWER JAW *(One-half).*

The same principles must guide as in the last operation. If the tumour be a simple one then keep close to it during the operation; but if, on the other hand, it is malignant, cut wide of it. The **instruments required** are the same as in the previous operation; in cases where a part only of the bone is removed, a match, or some similar piece of wood, partially sharpened, should always be at hand to plug the foramen in the bone, where the inferior dental artery lies, in order to stop the bleeding. The **Surgeon** stands on the right side. (1) Place the **patient** in a recumbent position, with the shoulders slightly raised, shave the part if necessary, extract an incisor tooth, fix the point of the tongue, and make the **incision** (Fig. 37, 2). Begin above and immediately behind the articulation of the lower jaw, but in front

of the temporal artery, and carry it deeply down to the bone along the ascending ramus of the jaw, and then forwards under the horizontal ramus, so that the resulting scar may be hidden, till opposite the point where the bone is to be divided, and then carry it upwards towards, but do not divide the lip; but the lip may be divided completely, as it really does not matter since it unites readily enough, and the saving of it might embarrass the operator. In the case of a simple tumour of limited extent, or in the case of a female, an attempt may be made to do the whole operation by an incision under the jaw. Secure the facial artery before, or as soon as divided, by a catch forceps (WELLS's), and at once tie it. (2) Dissect this flap upwards and inwards to expose the bone and clear the inner side of the jaw from contiguous structures, using a narrow bistoury and keeping its edge close to the bone. (3) Saw through the jaw partially, close to the symphysis, and complete the division with the bone pliers. (4) Depress the divided ramus with the left hand, or lion forceps, till the insertion of the temporal muscle into the coronoid process is seen, and then divide it at its insertion. If this is impossible then snip off the coronoid process in the mean time, and remove it afterwards if necessary. (5) Turn the jaw outwards a little, still depressing it, to make the external ligaments of the joint tense, and open the joint *from the front*, and keep the edge of the knife close to the bone to avoid wounding the internal maxillary; in depressing the jaw it must not be rotated lest the artery in this way be stretched round the neck of the bone and be torn or divided. (6) Divide the insertions of the internal, and the external pterygoids; evert the bone, and carefully separate all the soft parts

from its inner surface, taking care not to injure the submaxillary gland or lingual nerve, and remove it. Secure the bleeding points, and close the incision, and drain from the lower and posterior angle. *Note.*—In making the incision it is better not to carry it too far up behind the ascending ramus (if the jaw can be disarticulated without doing so) lest the trunk of the facial nerve be severed, and the various facial muscles be therefore paralysed (the portio dura (*facial*) being the *motor* nerve of the face), but only curve it slightly over the angle of the jaw, and dissect up beneath this flap close to the bone. If, however, the nerve must be divided, its main branches should be sutured afterwards with fine catgut. In closing the wound it is better to stitch the two edges of the divided mucous membrane together in order to shut the wound off from the cavity of the mouth; but a drainage tube must be passed through into the mouth. The wound and lip (if divided) must be sutured in the same way, and the after-treatment conducted on the same principles as in excision of the upper jaw—continuous irrigation with warm antiseptic fluid. In the case of simple tumours, whenever possible, the alveolus should be divided and the border of the jaw preserved.

Chief Structures Divided.—(1) Superficial structures, fascia and platysma. (2) *Muscles*, viz., masseter, platysma, part of buccinator, insertion of digastric (anterior belly), genio-hyoid, genio-hyo-glossus of the side excised (if the incision be through the symphysis), mylohyoid, a few fibres of the superior constrictor of the pharynx, internal and external pterygoids, depressor labii inferioris, temporal, levator menti, and orbicularis oris. (3) Probably a part of parotid gland. (4) Stylo-

maxillary ligament. (5) *Nerves*, viz., inferior dental, small twigs of the facial, part of the auriculo-temporal, mylohyoid, and masseteric. Care must be taken to preserve the conjoined chorda tympani and lingual from injury. They lie on the internal pterygoid, and are covered by the external pterygoid; the chorda being the nerve of taste to the anterior two-thirds of the tongue, while the lingual is the nerve of common sensation to the same part. (6) *Arteries*—Inferior dental, facial and its submental branch, inferior coronary, inferior labial, mental and masseteric, and other small muscular branches. The internal maxillary may be cut, or even the external carotid near the point where it divides into temporal and internal maxillary.

The care necessary in disarticulating the jaw will be evident when one remembers the close relation of various important structures to it, such as: Internal maxillary artery, auriculo-temporal nerve with the middle meningeal artery between its two heads of origin, and the chorda tympani close to the Glasserian fissure.

Excision of the *central* part of the lower jaw is always a dangerous operation. There is the risk of suffocation from the retraction of the hyoid bone and tongue when the attachments of the mylo-hyoid, genio-hyoid, and genio-hyo-glossi muscles are divided from the bone. To prevent this as far as possible the tongue must be fixed by a strong ligature passed through its tip, and held well out by an assistant. For the same reason it is better in excision of one side of the lower jaw not to cut through the symphysis exactly, but a little external to it, so as to leave the insertions of the genio-hyoid and the genio-hyo-glossus muscles.

THE OS CALCIS.

In excising this bone avoid making any incision in the sole. For this purpose the best form of incision to use is the following:—The patient is laid on his face, and a horse-shoe-shaped incision is carried from a point a little in front of the calcaneo-cuboid articulation round the heel and along the side of the foot to a corresponding point on the opposite side. The flap thus outlined is then dissected down over the prominence of the os calcis, keeping the edge of the knife close to the bone, exposing the whole of its under surface. Then a perpendicular incision is made, about two inches long, behind the heel and through the tendo Achillis, opening into the former incision; the tendon is then divided, and the flaps dissected up, and the knife passed between the os calcis and the astragalus, and the strong interosseous ligament divided, and lastly, its attachment to the cuboid is divided and the bone removed. Great care is necessary in clearing the inner side of the os calcis from the large number of vessels, nerves, and tendons at that side.

Structures Divided.—(1) Skin, superficial and deep fascia, and cutaneous vessels and nerves. (2) Muscles—tendo Achillis, extensor brevis digitorum, abductor minimi digiti, flexor brevis digitorum, plantaris, accessorius, and abductor hallucis, prolongation of tibialis posticus to lesser process, some also divide the peroneus longus and brevis. (3) Arteries—chiefly malleolar and calcanean twigs. (4) Ligaments—superior calcaneo-cuboid, internal calcaneo-cuboid, superior calcaneo-scaphoid, external calcaneo-astragaloid, middle fasciculus of external lateral ligament of the ankle

joint, posterior calcaneo-astragaloid, part of deltoid ligament, inferior calcaneo-scaphoid, long and short calcaneo-cuboid ligaments, and lastly, the strong inter-osseous ligament.

THE ASTRAGALUS.

This bone may be excised by an external incision, similar to that used in excision of the ankle joint, with, if necessary, a short straight incision over the internal malleolus, sufficient to allow division of the internal lateral ligament. Some divide the peroneus brevis and tertius, but it is better not to do so. The steps of the operation resemble closely those of excision of the ankle joint. It is important to clear the bone on all sides before separating the structures on the posterior edge—the flexor longus hallucis tendon, posterior tibial vessels, and posterior tibial nerve. The various *ligaments* connecting the bone with its fellows must be divided as they present themselves:—to the bones of the leg, os calcis, and scaphoid—(1) to the bones of the leg — the anterior ligament, posterior ligament, and lateral ligaments of the ankle joint (the middle fasciculus of the external lateral may be saved). (2) With the scaphoid—one, the superior astragalo-scaphoid. (3) With the os calcis—the strong interosseous, external and posterior calcaneo-astragaloid.

THE CLAVICLE.

The more important relations of this bone are—In *front*, skin, superficial fascia, platysma, and the descending branches of the supra-clavicular nerves, deep fascia, and communication from the cephalic to the external jugular vein. *Behind*—(1) *Vessels*—Subclavian vein, internal

jugular vein, and probably the junction of these two to form the innominate vein, external jugular vein, internal mammary artery, and supra-scapular artery and vein, the subclavian artery, common carotid artery, and partly the innominate artery; (2) *Nerves*—the vagus, phrenic, the great cords going to form the brachial plexus, the nerve of Bell, nerve to the subclavius, and cardiac nerves. (3) *Muscles*—sternohyoid, sternothyroid, omohyoid, scalenus anticus; (4) apex of the pleura and lung; (5) thoracic duct; (6) trachea; and (7) œsophagus. The last two are not exactly behind, but they are not far from the inner end. In excising this bone an important point is to secure free access. After the bone is exposed one of three courses may be pursued—either (1) to disarticulate at the sternal end, and gradually turn the bone outwards; (2) disarticulate at the acromial end, and turn the bone inwards; or (3) divide the bone with chisel and mallet at some convenient part of its length, if possible so that the outer fragment is the longer, as that end is the most difficult and dangerous to deal with, and remove it in two parts. I have only seen this operation performed once—for malignant disease of the bone; on this occasion Professor Chiene was the operator. He exposed the clavicle by a free crucial incision, but, according to his custom, made in such a way that the four angles do not all meet at one point. The flaps were then raised, and the bone divided about one inch from its sternal end. Round the inner end of the outer and larger fragment a strip of bandage was tied, by which the clavicle was gradually raised, as it was freed from its surroundings. The difficult part of the operation was the division of the coraco-clavicular ligament; this he divided by a probe-pointed bistoury,

after which the removal of the bone was an easy matter. The inner end was then freed from its attachments, the joint opened, and the bone removed by division of the strong costo-clavicular, or rhomboid, ligament. The only vessel of any size cut during the operation was the supra-scapular artery; twigs of the superior thoracic and acromio-thoracic would probably also be divided. In this operation great care is necessary lest any of the large veins be cut; the great risk of this accident would be the entrance of air, and probably fatal syncope on account of the aspirating power of the thorax. The care requisite is all the greater since the veins are most anterior. The wound is then closed, and drainage secured from the outer angle; this is the deepest part of the wound, and at the bottom lies the third part of the subclavian artery. One must therefore be careful in the management of the tube, lest it ulcerate into the vessel. The arm must be bound firmly to the side during the after treatment, pretty much in the same way as is done in fracture of the clavicle.

The Structures Divided.—(1) Skin, superficial fascia, platysma, sternal, clavicular, and acromial twigs of supra-clavicular nerve, twigs of acromio-thoracic artery, communication from cephalic vein to external jugular, and deep fascia. (2) Muscles—pectoralis major, deltoid, clavicular head of sterno-mastoid, part of the sterno-hyoid, trapezius and subclavius. (3) Ligaments—of the sterno-clavicular articulation, including the rhomboid; of the acromio-clavicular articulation, including the conoid and trapezoid. In this case also the supra-scapular artery, on account of the position and nature of the tumour.

THE SCAPULA.

This may be removed by a crucial or ⊣-shaped incision. By the ⊣-incision, an incision is made from the acromial end of the clavicle downwards along the axillary border of the scapula to its inferior angle; from the middle or upper third of this incision another is made at right angles, extending to the posterior border of the bone near the root of the spine. The patient is placed in a semi-prone position, and an assistant commands the subclavian artery by digital compression or a padded key. The flaps are then dissected up, and the acromio-clavicular joint opened. The suprascapular artery is next found (by feeling for the notch in the upper border of the bone and the transverse ligament, *over* which the vessel passes) and secured; then the posterior scapular is looked for under the levator anguli scapulæ, and also secured. The attachments of the posterior border are then divided and the bone drawn backwards and outwards; then the muscles attached to the coracoid process are divided. Next the shoulder joint may be opened by dividing the subscapularis tendon and the other tendons surrounding the neck of the bone. In doing so avoid the trunk of the subscapular artery and the posterior circumflex.

Structures Divided.—(1) Skin, superficial fascia, branches of dorsal nerves, and deep fascia. (2) Muscles—supra-spinatus, infra-spinatus, teres major, teres minor, deltoid, trapezius, subscapularis, serratus magnus, the rhomboids—major and minor, levator anguli scapulæ, omo-hyoid, long head of triceps, pectoralis minor, coraco-brachialis, short head of biceps, long head of biceps, and, in some cases, the latissimus dorsi.

(3) Arteries—suprascapular, posterior scapular, acromial branch of thoracic axis, dorsalis scapulæ and termination of subscapular. (4) Ligaments—of the shoulder joint, of the acromio-clavicular joint, conoid and trapeziod ligaments.

CHAPTER XXVI.

THE EYE.

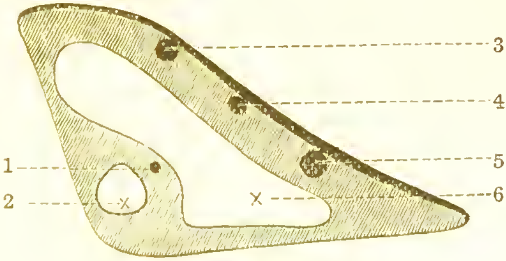
THE ORBIT.

The cavity of the orbit resembles a four-sided pyramid, the antero-posterior diameter of which is slightly larger than either the vertical or transverse. Its **apex** is formed of the optic foramen; the **base** is surrounded by the frontal, malar, and superior maxillary bones. The **roof** is formed of the frontal bone and lesser wing of the sphenoid; the **floor** by the orbital plate of the superior maxilla, the malar bone, and orbital surface of the palate bone. On the **inner wall** we find the nasal process of the superior maxilla, the lachrymal bone, the *os planum* of the ethmoid, and the body of the sphenoid; the **outer wall** is formed by the malar bone and the great wing of the sphenoid. The **openings** into the orbit are nine in number—(1) The optic foramen, which transmits the optic nerve and the ophthalmic artery; (2) sphenoidal fissure (for structures passing through, see after); (3) spheno-maxillary fissure, which transmits the superior maxillary nerve, with its orbital branch, the infra-orbital artery, and the ascending branches from Meckel's ganglion. This fissure opens a communication between three fossæ and the orbital cavity—the temporal, zygomatic, and spheno-maxillary; it will, therefore, be readily understood how malignant

growths can so easily and rapidly spread in both directions—*e.g.*, the rapidly growing forms of sarcomata, which are the tumours most frequently met with in this situation. (4) Supra-orbital foramen, for supra-orbital vessels and nerves; (5) infra-orbital canal for infra-orbital vessels and nerve; (6) anterior ethmoidal foramen for nasal nerve and anterior ethmoidal vessels; (7) posterior ethmoidal foramen, for posterior ethmoidal vessels; (8) malar foramina, for temporal and malar branches of orbital nerve; (9) lachrymal groove for lachrymal sac.

Cavernous Sinus and Sphenoidal Fissure *(foramen lacerum anterius).*—The cavernous sinuses are situated at the sides of the body of the sphenoid bone, and are so named from their presenting a reticulated or cavernous structure. Each sinus begins at the sphenoidal fissure,

Fig. 38.



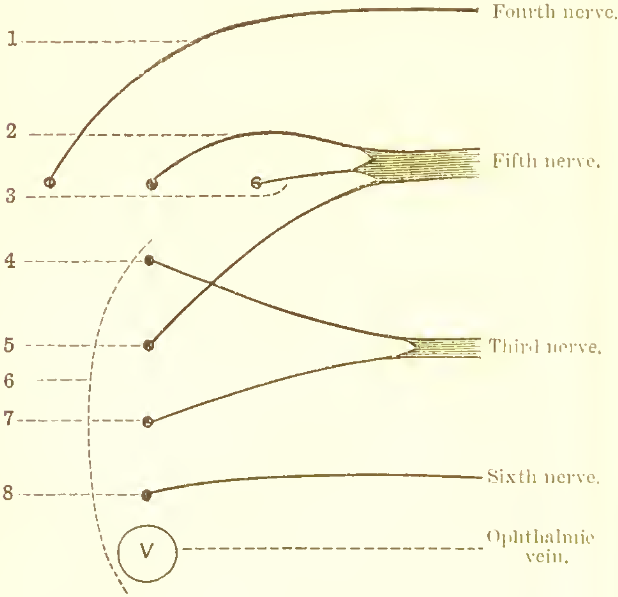
RIGHT CAVERNOUS SINUS.

1. Sixth nerve. 2. Internal carotid artery. 3. The third nerve. 4. The fourth nerve. 5. The first division of the fifth nerve. 6. The venous channel.

receiving the ophthalmic vein, and ends at the apex of the petrous portion of the temporal bone by dividing into the superior and inferior petrosals; they are connected by means of the circular sinus, and sometimes also by the transverse sinus. On the *inner* wall of

each sinus is found the internal carotid artery surrounded by the carotid plexus and with the sixth nerve to its outer side; on the *outer* wall are the third, fourth, and first division of the fifth nerve, in that order from above downwards (Fig. 38). Through the centre of this sinus the blood flows in an irregular

Fig. 39.



RIGHT SPHENOIDAL FISSURE.

1. Fourth nerve. 2. Frontal of fifth. 3. Lachrymal of fifth 4. Superior division of third. 5. Nasal of fifth. 6. Structures between the two heads of the external rectus. 7. Inferior division of third 8. Sixth nerve.

endothelial lined channel. In the sphenoidal fissure the position of parts is considerably altered—(1) The fourth nerve to the inner side; (2) the frontal branch of the fifth; (3) the lachrymal branch of the fifth. These three nerves are all above the muscles, and lie

nearly on one level, the fourth being to the inner side. Then come (4), the upper division of the third nerve; (5) nasal branch of the fifth; (6) lower division of the third nerve; (7) sixth nerve; and lastly, and most internal of all, (8) the ophthalmic vein. **Note.**—The structures named from 4 to 8 inclusive are all found between the two heads of the external rectus (Fig. 39).

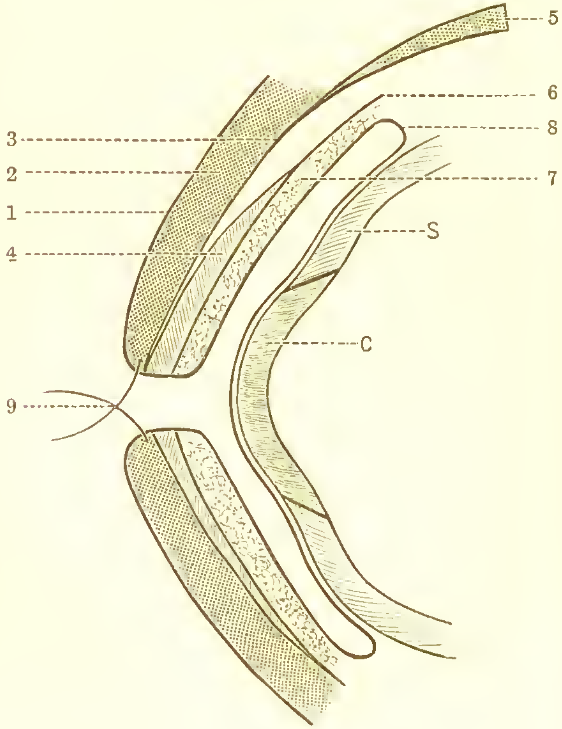
THE EYELIDS.

The eyelids are opened by the levator palpebræ, supplied by the *third* nerve, and shut by the contraction of the orbicularis oculi, supplied by the *facial* nerve. **Structure**—(1) The skin; (2) the orbicularis muscle; (3) loose connective tissue; (4) tendon of levator palpebræ (in the upper lid only); (5) tarsal cartilage, into the anterior and lower part of which the levator palpebræ is inserted; (6) palpebral ligament; (7) Meibomian glands; (8) conjunctiva, the mucous membrane of the eye, which lines the inner surface of the eyelids, and is reflected from them over the fore part of the sclerotic and cornea (Fig. 40).

The Eyeball (Fig. 41).—The eyeball consists of three coats, and the refracting media. The **outer coat** is formed by the sclerotic and cornea. (*a*) The *sclerotic* forms five-sixths of the circumference of the globe, and is composed of strong fibrous tissue, being thicker behind than in front. (*b*) The *cornea* forms the anterior sixth of the circumference of the globe, forming a small projection in front, being the segment of a smaller sphere than the sclerotic. The **middle coat** consists of the choroid, ciliary body, and iris. (*a*) The *choroid* is the vascular and pigmented coat of the eyeball, and is often the seat of melanotic sarcoma: (*b*) the *ciliary*

body consists of the ciliary processes and the ciliary muscle—the muscle of accommodation; (*c*) the *iris*, this is also a muscular structure, and forms a self-acting diaphragm, excluding or admitting light as required,

Fig. 40.



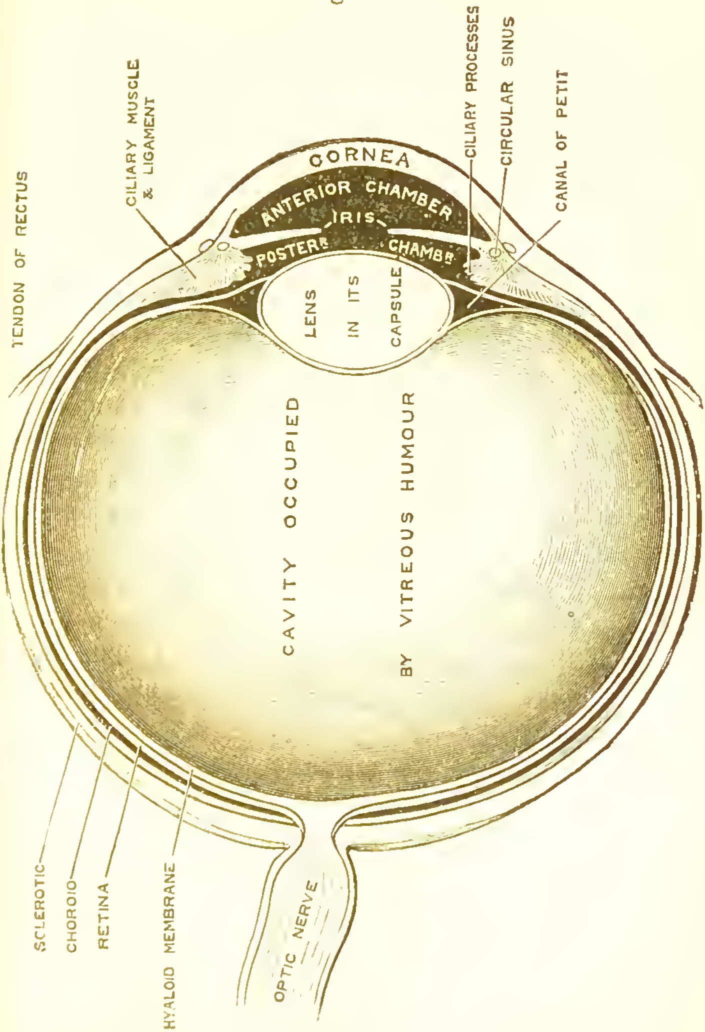
THE EYELIDS.

1. The skin. 2. Orbicularis palpebrarum. 3. Tendon of levator palpebræ. 4. Tarsal cartilage. 5. Levator palpebræ muscle. 6. Palpebral ligament. 7. Meibomian glands. 8. Conjunctiva. 9. The eyelashes. S. Sclerotic. C. Cornea.

like the diaphragm of a microscope, becoming narrower during active accommodation (equal to *high power* of microscope) and widening during passive accommoda-

tion (*low power*). The inner coat consists of the *retina*, which is formed by the expansion of the optic nerve,

Fig. 41.



ANTERO-POSTERIOR SECTION OF EYEBALL.
(From GRAY'S *Anatomy*.)

and is the *seeing* part of the eye. When looked at, by the aid of the ophthalmoscope, the following parts may be recognised (1) the *optic disc* or *blind spot*, one-tenth of an inch to the inner side of the axis of the eye; (2) the *macula lutea* or *yellow spot*, as nearly as possible in the axis of the eyeball; in its centre is a slight depression — the fovea centralis; (3) the *arteria centralis retinæ*, which enters through the optic disc and divides into four or five branches, which pass over the retina in various directions, but seem to avoid the macula lutea; (4) sometimes the vessels of the choroid may be seen.

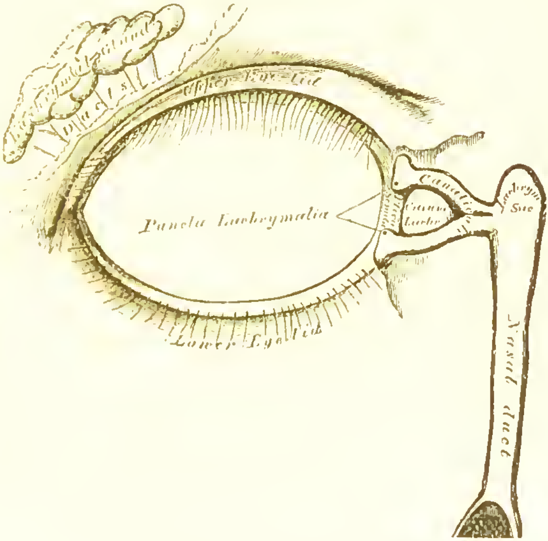
The **Refracting Media** of the eye are — (1) the **cornea**. (2) The **Aqueous Humour**, which fills the space between the cornea in front, and the lens with its suspensory ligament behind; this space is partially subdivided into two by the iris — the *anterior* and *posterior chambers* of anatomists. It should be noted, however, that oculists call the whole cavity the *anterior chamber*, their posterior chamber being the cavity containing the vitreous humour. (3) The **Lens** with its **Capsule**, which are held in position by the suspensory ligament. (4) The **Vitreous humour** with its **Hyaloid Membrane**.

THE LACHRYMAL APPARATUS.

This consists of—(1) The lachrymal gland and its ducts opening around the outer canthus, especially on the upper lid; (2) puncta lachrymalia, which are the openings into (3) the canaliculi, which lead into (4) the lachrymal sac, from which (5) the nasal duct descends to open into the inferior meatus of the nose (Fig. 42).

Puncta Lachrymalia and Canaliculi.—The puncta are two small apertures situated, one on the free margin of each lid, about one quarter of an inch from the inner canthus; they are the openings of two small ducts—the canaliculi. Each canaliculus takes a curved course inwards—the upper first passing upwards and then curving downwards; the lower first passing downwards and inwards, and then curving upwards and inwards;

Fig. 42.



THE LACHRYMAL APPARATUS.
(From GRAY'S *Anatomy*.)

and, therefore, in introducing a probe, the lid should be drawn outwards to straighten the canaliculus. The lower canaliculus is shorter, wider, and not so much arched as the upper, and is the one usually opened, both because it is easier, and also because it carries off most of the fluid. In doing this the edge of the knife is directed inwards, and passed first a little downwards

and a little inwards, and then inwards and very slightly upwards.

Lachrymal Sac.—If from any cause this sac requires to be opened (*e.g.*, when suppuration has occurred in it), it should be opened from the *outer* side, because the angular artery (the termination of the facial) and the large angular vein are on its inner or nasal side. The sac is placed in the inner angle of the orbit, and crossed by the tendo-oculi a little above its middle, and by the tensor tarsi muscle. If the finger be placed on the inner edge of the orbit, this tendon will be felt to tighten every time the eye is closed, and still more so if the eyelids are drawn outwards.

Nasal Duct.—This duct leads from the lachrymal sac to the inferior meatus of the nose. The edges of the canal through which it passes may be felt on one's own person, by pressing the finger on the inner edge of the orbit on its lower aspect. To pass a probe through it, it should be directed downwards, outwards, and a little backwards (the direction of the duct). Obstruction of this duct leads to distension, and consequently to irritation and disease of the lachrymal sac, and, unless properly treated, inflammation and suppuration follow, which may end in fistula lachrymalis. It is also a cause of 'Epiphora' ('watery eye' due to excessive secretion), or 'Stillicidium Lachrymarum,' ('watery eye' due to obstruction to outflow), trickling of tears over the cheek, 'watery eye.' Each duct opens into the anterior part of the inferior meatus of the nose, immediately below the junction of the anterior end of the inferior turbinated with the maxilla; they are about half-an-inch long, and they are narrowest about the middle.

'Watery Eye.'—This may be caused by—(1) Obstruction of the nasal duct from chronic thickening of the mucous and submucous tissue; (2) from increased secretion ('Epiphora'); (3) from obstruction of puncta or canaliculi from chronic inflammation or warty growths; (4) in cases where the puncta are displaced, as in facial paralysis; (5) suppuration of the sac from acute inflammation, probably following chronic thickening of its lining membrane with increased secretion of mucus, forming a little tumour (*mucocele* or *chronic dacryo-cystitis*), which is very apt to inflame and suppurate. In chronic cases the usual treatment is to open the inferior canaliculus. It is true probes might be passed, and the opening gradually dilated just as in ordinary stricture of the urethra; but this plan is exceedingly slow, painful, unnecessary, and not satisfactory even when performed. The quickest and best way is to open the canaliculus, thus transforming it from a round pipe into an open gutter. After twenty-four hours rest probes are passed down from the lachrymal sac into the nasal duct. Each probe must be kept in for ten or fifteen minutes (one probe at each sitting will usually be sufficient) and a larger size passed every second or third day. Before passing the probe Dr ARGYLL ROBERTSON curves it slightly, so that it may enter the duct more easily; he judges of the proper amount by placing the curved part against the side of the patient's nose and eyebrow just over the sac and duct, and when it lies level with the skin it is sufficiently curved. It is then passed along the opened canaliculus till the point comes into contact with the lachrymal bone, when the handle is raised till it lies over the supra-orbital notch, and the probe is then to

be pushed in the direction above indicated—downwards, backwards, and a little outwards.

SURFACE VESSELS OF THE EYEBALL.

By this is meant vessels that can be seen more or less distinctly with the naked eye in certain diseased conditions.

1. **The Vessels Proper to the Conjunctiva.**—These vessels are usually known as the posterior conjunctival branches, and are derived from the palpebral and lachrymal arteries. In health they are too small to be well seen, but in simple *conjunctivitis* they can be seen to perfection. They are of a bright brick-red colour, superficial, moving with the conjunctiva when it is slid over the globe, can be emptied for a time by gentle pressure, are tortuous forming open loops, largest at the circumference of the globe, and growing smaller as they approach the edge of the cornea.

2. **Vessels of the Iris.**—These are chiefly derived from (*a*) the two *long ciliary* arteries which pierce the posterior part of the sclerotic, and run forward along each side of the eyeball, between the sclerotic and the choroid to the ciliary ligament, where they each divide into two branches and form the great arterial circle of the iris, from which smaller branches pass to form the lesser circle at the pupillary margin. (*b*) The *anterior ciliary* arteries, which are derived from the muscular branches, and lie in the *sub-conjunctival* tissue, and divide into two sets of branches—(1) the *perforating* branches which pierce the sclerotic about a line from the edge of the cornea, and supply the sclerotic and ciliary body, and end in the great arterial circle of the iris. (2) *Episcleral* non-perforating branches which are too

small to be seen in health, but in *Iritis*, and some deep seated affections of the cornea, they form a zone ('circum-corneal zone') about an eighth of an inch wide surrounding the cornea, *pink* in colour, and consisting of closely packed, straight and very fine, radiating vessels. This injection is sub-conjunctival, and the vessels do not therefore move when the cornea is slid over the globe, nor can they be emptied or affected in any way by pressure. Marked as these differences are between the injection of iritis and conjunctivitis, yet iritis itself must not be diagnosed on these grounds alone, as other conditions produce the same injection. Besides the congestion in iritis, there is the altered colour of the iris, and sluggish action of the pupil to light; deep-seated pain shooting up the side of the head, nose, and eyebrow, which is usually worst in the early morning. There is further impairment of vision, and often great watering of the eye. In *conjunctivitis* the pain is smarting and superficial (like sand in the eye), the secretion is rather sticky than watery, and gums the lids together, and the vision is not impaired except for the moisture in front of the eye. It is very important to distinguish between conjunctivitis and iritis, as the treatment is so different, and the result of a mistaken diagnosis might be serious for the patient.

3. The veins corresponding to the anterior ciliary arteries *(the epi-scleral venous plexus)* are sometimes found to be engorged, forming a scanty reticulated zone of dusky colour, with sometimes the larger trunks standing out in a sharply defined manner. When this is the case it usually points to the serious condition known as glaucoma—a condition characterised by increased intra-ocular tension, the increased pressure

obstructing the circulation through the venæ vorticosa of the choroid.

The **cornea** itself in non-vascular, but in interstitial keratitis, where the cornea becomes like ground glass, a condition so frequently associated with congenital syphilis, blood vessels from the periphery often penetrate into *its substance*, at some little distance from the surface. This gives rise to a patch of peculiar colour—the 'salmon patch' of HUTCHINSON; with a lens the 'patch' can be seen to consist of a fine, straight, closely packed plexus of vessels. Also in the condition known as 'pannus' there is a new growth of very vascular tissue just beneath the corneal epithelium, over part of the surface (usually the upper part) of the cornea.

MOVEMENTS OF THE EYEBALL.

There are, in all, seven **muscles** acting on the globe—four recti, superior and inferior obliques, and the levator palpebræ superioris. Their nervous supply is as follows—the external rectus is supplied by the *sixth* nerve; the superior oblique by the *fourth;* and all the rest by the *third* or *motor oculi*, viz.:—Levator palpebræ superioris, superior rectus, internal rectus, inferior rectus, and inferior oblique.

Movements.—(1) To **raise** the eyeball the superior rectus and inferior oblique act together; the superior rectus pulls upwards and inwards, the inferior oblique pulls upwards and outwards, but acting together the eye is raised. (2) To **depress** the eyeball the inferior rectus and the superior oblique act together: the inferior rectus displaces the ball downwards and inwards, the superior oblique downwards and outwards, but both acting together the ball is displaced directly

downwards. (3) The external rectus **abducts** the eyeball, while the internal rectus (4) **adducts** it.

NERVES OF THE EYEBALL.

1. **The Optic Nerve.**—The deep origin of this nerve is from the optic thalamus, the anterior pair of corpora quadrigemina, the corpora geniculata, and, according to some authors, from the angular gyrus, where, according to FERRIER, the visual centre is situated; but MUNK, on the other hand, places the centre on the outer convex surface of the occipital lobe. From the deep origin each tract winds obliquely across the under surface of the corresponding crus and join each other to form the optic commissure. The optic nerves take origin from the commissure, pass through the optic foramina, pierce the sclerotic and choroid a little to the nasal side of the centre and expand into the retinæ. The exact course and origin of the fibres passing to each retina is still a disputed point; it is generally admitted that there is a partial decussation at the optic commissure, each tract supplying the corresponding half of each eye, *e.g.*, the left tract supplying the left half of each eye. Should therefore this tract be destroyed by disease, there will be blindness of the left half of both retinæ (which will, of course, correspond to the right half of each visual field). This is known as *Homonymous hemianopsia.* On the other hand a lesion situated in the anterior part of the optic commissure will produce blindness of the inner half of each eye (the right half of one eye but the left half of the other). This is called *internal heteronymous hemianopsia.* In the very rare condition of *external heteronymous hemianopsia* (blindness of the external half of each retina) there must be a double

lesion situated at the outer margins of the sides of the optic commissure. But *hemianopsia* may also be caused by other conditions, such as detachment of the retina, and in *Coloboma*—a congenital cleft or deficiency in the iris, and often in the choroid as well, always found at the lower and inner aspect, and therefore the upper part of the visual field is deficient. It is very often symmetrical. It is doubtful what would be the result of a lesion situated in the visual centre. Some believe that the fibres that do not decussate at the optic commissure have already decussated in the corpora quadrigemina, so that the right centre would in this way entirely supply the left eye. Others believe that each centre presides over the corresponding half of each eye.

2. **The Third Nerve** *(Motor Oculi).*—The deep origin of this nerve is from a grey nucleus just below the aquæductus Sylvii, and which is a continuation of the grey matter of the anterior horn of the spinal cord. It is also connected with the locus niger and the corpora quadrigemina. It lies in the outer wall of the cavernous sinus, where it receives communications from the fifth and sympathetic, after which it enters the orbit, through the sphenoidal fissure. The *extrinsic* muscles supplied by this nerve have been already named. It also supplies two muscles *within* the eye—the *sphincter pupillæ*, and the *ciliary muscle*, by which the eye is accommodated for near objects. In looking at a near object *three* distinct events take place—(1) contraction of the ciliary muscle; (2) contraction of the pupil; (3) convergence of the eyeballs (by the internal recti), all accomplished by the third nerve. In health a definite relationship exists between these

three movements, which, if disturbed, will lead to defective sight. The centre for the reflex contraction of the pupil is in the corpora quadrigemina or medulla oblongata.

Results of Paralysis.—(1) Ptosis, drooping of the upper eyelid, because the levator is paralysed; (2) external squint, as there is nothing to oppose the external rectus, which is supplied by the sixth nerve which is not affected; (3) double vision, as the images are not thrown on corresponding parts of the two retinæ; (4) dilatation of the pupil, as the sphincter is paralysed, and further, it is insensible to light; (5) loss of accommodative power for near objects, as the sphincter pupillæ, ciliary muscle, and internal recti are paralysed; (6) immobility of the eye in all directions; (7) the globe is slightly more prominent, due to the action of the superior oblique (fourth nerve), which is not paralysed.

The squint in this case is *paralytic*, and the movements of the squinting eye are extremely limited (in contra distinction to *concomitant* squint, where the squinting eye retains its full range of motion). It is also *divergent*, and the double images are therefore crossed, *i.e.*, the image belonging to the right eye appears to be to the left of the other *(Heteronymous squint)*, in other words the right hand image belongs to the left eye, and *vice versâ*. This is ascertained in a darkened room by means of a candle held about six feet from the patient, and a strongly coloured glass, by means of which one can tell which of the two images belongs to each eye. As the paralysed eye cannot move upwards nor downwards, as the candle is moved the height of the images will vary according as

the candle is above or below the horizontal plane, and the position of the images will be understood by remembering that the lower part of the visual field corresponds to the upper part of the retina and *vice versâ.*

The Fourth Nerve.—The deep origin of this nerve is from the nucleus of the third in the Aquaduct of Sylvius. It also communicates with the motor nucleus of the fifth. It passes through the outer wall of the cavernous sinus, and enters the orbit through the sphenoidal fissure, and then enters the orbital surface of the superior oblique. The function of this muscle is to turn the eye downwards and outwards. Paralysis of the nerve gives rise to little sign, unless the patient looks below the horizontal level, when the paralysed eye lags behind the other, and is also twisted inwards by the inferior rectus. The squint is paralytic and *convergent*, and, therefore, the images are not crossed *(Homonymous squint), i.e.*, the right hand image belongs to the right eye, and *vice versâ.* As the eye is turned downwards, the false image is always below the true and leans towards it.

The Fifth Nerve.—Only the first division concerns the eye. It is the sensory nerve of the eyeball, and probably trophic in function as well; it also supplies the lachrymal gland, eyebrow, forehead, and nose. This explains why in deep seated affections of the globe, such as iritis, there is pain over the eyebrow, and down the side of the nose, and also the increased lachrymation. It also supplies the mucous membrane of the nose, and hence irritation of this surface, as by snuff or the volatile oil of mustard, is often accompanied by increased lachrymation. If the nerve is

paralysed there is loss of sensation in the various parts supplied, and also destructive inflammation of the cornea.

The Sixth Nerve.—This nerve arises from a nucleus in the upper part of the floor of the fourth ventricle, continuous with the grey matter of the anterior horn of the cord, common to it and the portio dura of the seventh. It passes along the inner wall of the cavernous sinus close to the internal carotid artery, and enters the orbit through the sphenoidal fissure and supplies the external rectus. The result of paralysis of this nerve is internal squint (convergent). Being convergent it is therefore homonymous, *i.e.*, just as in the paralysis of the fourth, the right hand image belongs to the right eye and *vice versâ*.

The Sympathetic Nerve in Relation to the Eye.—In addition to its ordinary vaso-motor action, the sympathetic is the motor nerve to the **dilator pupillæ**, and also to MÜLLER'S muscle—non-striped muscular tissue bridging across the sphenoidal fissure. The centre is probably situated in the medulla, but the fibres pass down the cord some little distance *(cilio-spinal region)*, leaving it in the last cervical and first dorsal nerves, and entering the corresponding ganglia of the sympathetic trunk, up which they pass to the base of the skull, then along the plexus around the internal carotid artery *(carotid* and *cavernous* plexuses) and joins the ophthalmic division of the fifth, forming part of its nasal branch, and thence through the long ciliary twigs of the nasal nerve to the radiating fibres of the iris. The stimulus for these fibres is the *absence* of light; they are also stimulated by the stimulation of other sensory nerves, *e.g.*, severe pain dilates the pupil.

and also of the venous condition of the blood, as seen in the dilation of the pupil in dyspnœa.

Mr Hutchinson, in his '*Illustrations of Clinical Surgery*,' shows very beautifully the effect on the eye, produced by paralysis of the cervical sympathetic—(1) The eyeball is retracted within the orbit, probably from paralysis of the muscle of Müller. (2) The pupil is contracted *in the shade;* the paralysis simply prevents dilatation, but does not *cause* contraction. (3) The palpebral aperture is apparently narrowed from the slight drooping of the upper eyelid, probably from the paralysis of some smooth muscular fibres situated there, and also from the recession of the globe.

EXCISION OF THE EYE.

This may be rendered necessary for—(1) '*Sympathetic*' *opthalmia* (ophthalmitis), usually due to some wound, accidental or operative, in the ciliary region of the eye—a zone about a quarter of an inch wide surrounding the cornea, often spoken of as the '*dangerous zone*' of the eye. (2) In cases of wounds, where the vision is destroyed and the foreign body cannot be found. (3) In pan-opthalmitis. (4) General staphyloma of the globe or large staphyloma of the cornea. (5) For the removal of tender irritable stumps. (6) Tumours of the interior, *e.g.*, glioma of the retina, or melanotic sarcoma of the choroid. **Instruments required.**—(1) Spring speculum; (2) blunt pointed scissors curved on the flat; (3) fixation forceps; (4) strabismus hook; (5) sponges, lint, and wool; (6) ice-cold water; (7) styptic, such as perchloride of iron; (8) fine needles and silk sutures; (9) chloroform, &c. The **operator** may most con-

veniently stand behind the patient. Introduce the speculum and divide the ocular conjunctiva all round close to the edge of the cornea, beginning at the upper part, with the scissors. Then raise up the conjunctiva and divide *Tenon's capsule* also with the scissors, and then with the strabismus hook, hook up and divide the recti one after the other capsule and all; the superior oblique may also be divided on the hook, but the inferior is left for the present. Now make the eye start forwards by pressing the spring speculum behind the globe and then pass the curved scissors from the outer side, round the sclerotic and divide the optic nerve and remove the globe, by dividing the inferior oblique and any remaining soft parts. Then at once plug up the opening by compresses of cotton wool wrung out of some antiseptic; this is for the purpose of controlling hæmorrhage by pressure. The cut edges of the conjunctiva may or may not be brought together by sutures, according to the inclination of the operator. Pressure must be kept up for six or eight hours by means of sponges or cotton wool. If this operation is performed for malignant tumours of the orbit (sarcomata) the whole contents must be cleared out; for simple conditions a less radical method will suffice, the chief thing to be kept in mind being that whatever else is left the *corneal tissue must* be all removed.

Structures Divided.—The ocular conjunctiva; the capsule of tenon; the four recti; the two obliques; the ciliary arteries and nerves; the optic nerve with the arteria centralis retinæ; branches of the third and fifth nerves; twigs of the ophthalmic artery and vein.

CHAPTER XXVII.

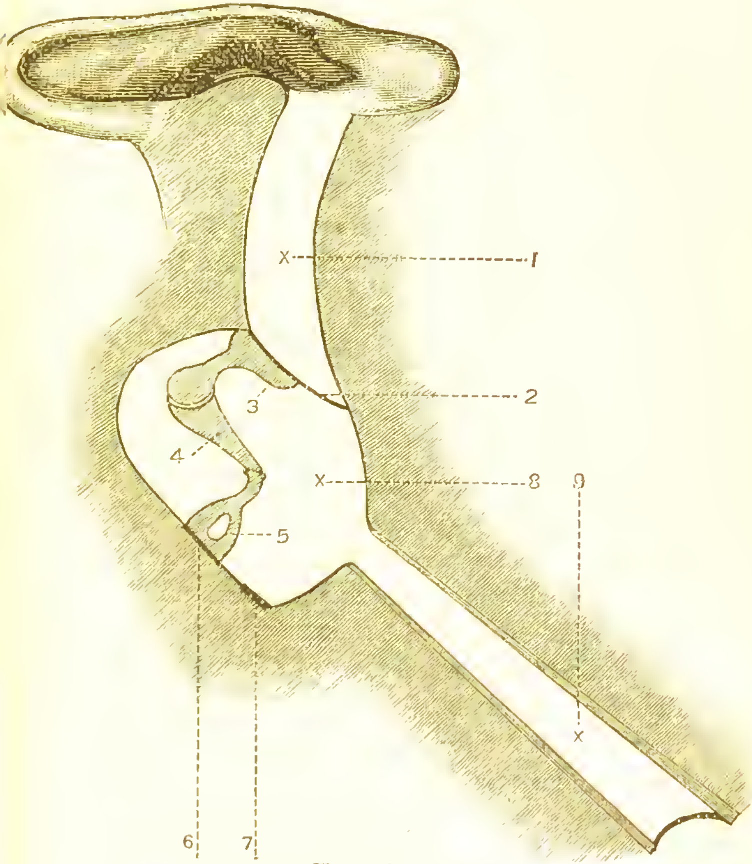
THE EAR.

EXTERNAL AUDITORY MEATUS.

This meatus is about an inch and a quarter in length; the lower wall is the longest on account of the oblique direction of the membrana tympani, which forms an angle of 45° with the horizon, in the adult. In the child, however, the membrane is more nearly horizontal, forming only an angle of 10° with the horizon, but as age advances this gradually increases. It passes obliquely forwards and inwards, and is curved upon itself, the concavity pointing downwards, so that its floor is convex; it is also curved a little forwards. Its shape is oval, with the long axis vertical, and it is narrowest about the middle, and, therefore, the ear speculum should not be introduced beyond this point. Rather less than one-half its length is formed of cartilage, the rest of bone. In young children, however, there is practically no bony part, and in them, therefore, the meatus is very short. In examining the membrana tympani, the pinna should be pulled upwards and backwards in order to straighten the meatus as much as possible. In health, the membrana tympani is smooth and shining, and has a slate blue colour, and it is concave from the outside. Besides seeing the membrana (by means of the speculum and mirror), we also

see the handle and short process of the malleus (which are situated between the outer and middle layers of

Fig. 43.



THE EAR.

1. External auditory meatus. 2. Membrana tympani. 3. Malleus. 4. Incus. 5. Stapes. 6. Membrane shutting off the tympanic cavity from the vestibule. 7. Membrane in the foramen rotundum, shutting off the tympanic cavity from the scala tympani of the cochlea. 8. Tympanic cavity. 9. Eustachian tube.

the membrane) and that appearance known to aural surgeons as the 'triangle of light,' an appearance due

to the peculiar curvature of the membrane, the rays from the two sides crossing each other at the anterior and lower part.

Structure of the Membrane.—It consists of three layers—(1) The outer, or cuticular layer, a continuation of the skin of the meatus. (2) The internal, or mucous layer, which is continuous with the mucous membrane of the tympanic cavity; in a fold of this layer the chorda tympani nerve lies concealed. (3) The middle, or fibrous layer, consisting of connective tissue fibres arranged both radially and circularly—the *radial* are the most numerous, and radiate from the point of attachment of the handle of the malleus; the *circular* form a dense ring near the circumference, and are lodged in a bony groove. This layer is defective above, and here, therefore, the membrane is only composed by the cuticular and mucous layers; this part is known as the *membrana flaccida.* **Nerves** of the meatus. The principal nerves are derived from the *ariculo-temporal*, which is a branch of the third division of the fifth nerve; the *great auricular* from the cervical plexus, and the *auricular branch* of the vagus (Arnold's *nerve*). These nerves and their communications explain the occasional peculiar results of irritation of the external auditory meatus—such as coughing and sneezing from irritation of Arnold's nerve, and yawning from irritation of the auriculo-temporal nerve, the impulse passing to the muscles that open the jaws. The **vessels** of the meatus are derived from the posterior auricular, internal maxillary, and temporal arteries.

THE MIDDLE EAR OR TYMPANUM.

This is a small six-sided cavity somewhat com-

pressed from side to side, situated in the substance of the temporal bone, and containing air. It communicates with the pharynx by means of the Eustachian tube. It is placed immediately above the jugular fossa; in front is the carotid canal, with the internal carotid artery; behind the mastoid cells; externally the membrana tympani and external auditory meatus, and internally the labyrinth. **BOUNDARIES**—1. The **roof** is a thin plate of bone separating the cranial from the tympanic cavity. 2. The **floor** is formed by the meeting of the outer and inner walls, and is immediately above the jugular fossa; in the floor is a small aperture for the entrance of JACOBSON'S nerve (from the glosso-pharyngeal). 3. The **outer wall** is the membrana tympani. At the lower part of this wall there are three openings—the *glasserian fissure*, which gives passage to the laxator tympani muscle, the tympanic vessels, and lodges the processus gracilis of the malleus; and the *iter chordæ posterius et anterius*, being the apertures of entrance and exit of the chorda tympani nerve. The *iter chordæ anterius* is the beginning of the canal of HUGUIER. The chorda tympani is the nerve of taste to the anterior two-thirds of the tongue, and passes across the cavity from back to front, close to the outer wall, between the handle of the malleus and the long process of the incus, being invested by a fold of the mucous membrane forming the most internal layer of the membrana tympani. It is easy to understand, therefore, how this nerve may be implicated by disease of the middle ear, and its function consequently destroyed or altered. 4. The **inner wall** is vertical, and looks almost directly outwards. On this wall note—(*a*) The *fenestra ovalis*,

a depression which leads to the vestibule, but which is closed by a membrane similar in structure to the membrana tympani; the depression is occupied by the base of the stapes. (*b*) The *fenestra rotunda*, a depression which leads to the seala tympani of the cochlea. It is also closed by a membrane resembling the tympanie membrane in structure. (*c*) The *promontary*, a hollow prominenee formed by the first turn of the cochlea; it is placed anteriorly and between, the two fenestræ and is grooved by the nerves of the tympanic plexus. (*d*) The rounded eminence of the *aquæductus Fallopii* which lodges the facial nerve. (*e*) The *pyramid;* it contains the stapedius muscle, and has a small opening at its apex for the exit of the tendon of that muscle, there is also a minute canal for the nerve to the stapedius—from the facial. (5) In the **posterior wall** are the openings of the mastoid cells, one large (the mastoid antrum) and several smaller openings. (6) **Anterior Wall.**—In this we find—(*a*) The canal for the tensor tympani; (*b*) the processus cochleariformis, a process of bone which separates the above from (*c*) the Eustachian tube which is the lower and larger of the two openings. By this tube the middle ear communicates with the nasal part of the pharynx. Its length is from one and a half to two inches, and its direction is downwards, forwards, and inwards. It consists of—(*a*) An osseous part about half an inch in length, situated in the temporal bone. (*b*) A cartilaginous part about an inch in length of triangular shape and composed of hyaline cartilage. The open part is below, and it is completed by a fibrous membrane and a layer of voluntary muscle; it ends in a trumpet-shaped mouth nearly on a level with the

inferior meatus of the nose. It is lined by ciliated epithelium, the cilia of which lash downwards; it is usually closed, but is opened at the moment of swallowing by the *dilator tubæ* muscle. Its use is to get rid of secretions from, and to ventilate the tympanic cavity. By its means the pressure of air in the cavity is kept the same as in the external auditory meatus, so that the pressure on each side of the membrane is the same.

The external auditory meatus, the tympanic cavity, and the Eustachian tube, are all **developed** from the upper part of the *first branchial cleft.*

The **arteries** of the tympanum are—(1) Tympanic branch of the internal maxillary; (2) the stylo-mastoid branch of posterior auricular; (3) petrosal branch of middle meningeal entering through the hiatus Fallopii; (4) a branch from the ascending pharyngeal passing up the Eustachian tube; (5) a small twig from the internal carotid artery, entering through the anterior wall of the cavity. Its **Nerves** are (1) the tympanic branch of the glosso-pharyngeal (*Jacobson's nerve*), which enters through an aperture in the floor of the cavity, and is distributed to the Eustachian tube, foramen ovale, and foramen rotundum, and communicates with (2) twig from carotid plexus, (3) twig from great superficial petrosal, and (4) sends a twig to join the lesser superficial petrosal.

EUSTACHIAN TUBE.

The open trumpet-shaped mouth of this tube is situated on a level with the posterior extremity of the inferior turbinate bone. According to TILLAUX the opening is about half an inch below the basilar process;

half an inch in front of the posterior wall of the pharynx; half an inch behind the posterior extremity of the inferior turbinated bone; and half an inch above the soft palate. In this way the nasal part of the pharynx of one side may be regarded as a little box one inch square, and in the centre of its outer side is placed the opening of the tube. Immediately behind the orifice of the Eustachian tube is a depression known as the fossa of ROSENMÜLLER, into which the point of the catheter may be inadvertently slipped. Obstruction of the tube gives rise, if not to deafness, at least to considerable impairment of hearing, from indrawing and rigidity of the membrana tympani, and it will be necessary to adopt some means to get rid of the obstruction.

1. This may be attempted by **Valsalva's Method,** directing the patient to hold his nose between the finger and thumb of one hand, close the mouth, and expire forcibly. If at the same time the patient is directed to swallow, the effect will be all the more evident.

2. **Politzer's Method.**—This method for forcing air up the Eustachian tube takes advantage of the physiological fact, that during deglutition the opening from the mouth into the upper part of the pharynx and posterior nares is closed, and also at the same time the Eustachian tube is opened by the dilator tubæ or tensor palati, and by the Salpingo pharyngeus. Every time one swallows it is possible to hear a 'click' in the ear due to the air being forced up the Eustachian tube and impinging on the membrana tympani, and this is rendered much more evident if the nostrils are closed by grasping the nose with the finger and thumb. By these means we have really an air-tight chamber, and

if any of its walls are squeezed or forced inwards, or if more air be driven in, the air being practically incompressible is driven in the direction of the least resistance, *e.g.*, up the Eustachian tube. The patient is directed to take a mouthful of fluid, and, at a given signal from the operator, to swallow it. The operator introduces the end of a tube (the other end of which is in communication with a small reservoir of air) into one nostril, and closes the nostrils with the finger and thumb of one hand, while with the other hand he grasps the air-bag. He then directs the patient to swallow, and as he does so, the operator projects into the nostril a quantity of air, which increases the pressure, and some of it passes up the Eustachian tube into the tympanum. It will be seen that this method resembles VALSALVA'S very closely, only by means of the air-bag greater pressure can be brought to bear upon any obstruction that may be present in the tube. Instead of taking a mouthful of water other plans may be adopted, such, for example, as asking the patient to say 'Huck' (GRUBER), or a still more convenient plan of simply directing the patient to puff out the cheeks (HOLT). In cases where the patient or Surgeon are doubtful whether the air has or has not entered the cavity, one of the patient's ears must be connected with that of the Surgeon by a flexible rubber tube. In this way the Surgeon will be able to tell whether the air enters the cavity in the usual amount and with the usual force, or feebly, or not at all, according to the presence or absence of stenosis of the Eustachian tube; also, whether there are super-added sounds, such as bubbling or crackling from the presence of fluid in the cavity, or whether a whistling sound is heard, due

to the air passing right through the membrane and tube into the Surgeon's ear, on account of a perforation of the membrana tympani.

3. If the above means fail, then recourse must be had to the **Eustachian Catheter.** The catheter may be made of various materials, hard rubber, vulcanite, silver, &c. It is curved at the end which is passed into the tube; at the other end it is expanded so as to fit the nozzle of the air bag, and also has a ring which corresponds to the concave side of the curve at the point, so that it indicates the position of the point of the instrument when it is lost to sight. The Surgeon connects his ear with the diseased ear of the patient by means of the flexible tube. The patient sits facing the light, with his head leaning slightly backwards, the mouth open and breathing easily. The Surgeon stands in front of the patient with the air bag under his left arm, and with his left hand slightly raises the tip of the patient's nose, and with the right passes the catheter along the floor of the inferior meatus, with its point downwards, and pushes it gently onwards till the posterior wall of the pharynx is reached. After this, the method recommended by Dr McBride, Aural Surgeon to the Royal Infirmary, is to turn the point of the instrument inwards towards the median line through a quarter of a circle, and then withdraw it till the curve at the point is caught by the nasal septum, when it is again rotated, through half a circle this time, so that its point is brought at right angles to the lateral wall of the pharynx, and then, if it is not in the tube, a little pressure of the beak outwards, produced by moving the other end of the tube inwards, will cause it to enter the orifice. To place the point of the

instrument into the exact course of the tube the ring at the outer end should point to the outer canthus of the corresponding eye.

THE INNER EAR OR LABYRINTH.

The osseous part simply consists of certain cavities scooped out in the petrous portion of the temporal bone. The whole is lined by a thin periosteal membrane, and filled with peri-lymph *(Liquor Cotunnii)*. The membranous parts are much smaller than the osseous, but are contained in the osseous part and surrounded by the peri-lymph. It consists of a system of tubes and bags, which are all connected together, forming a completely closed system, the cavities of which have no direct communication with the osseous cavities. The membranous labyrinth contains endo-lymph *(Liquor Scarpæ)*.

The **Nerve of Hearing** *(auditory* or *portio mollis* of seventh) is distributed to the different parts of the internal ear. The *vestibular* division is distributed to the utricle and saccule, and to the three ampullæ of the semi-circular canals, where it ends in peculiar hair cells. The *cochlear* part is distributed to the cochlea, being believed to end there in the 'organ of Corti.'

EXAMINATION OF THE EAR.

The hearing power may be first tested by ordinary speech, whispering, or the ticking of a watch. Deafness may be due to faults in the sound perceiving or the sound conducting parts of the ear. The **internal ear,** where the sound perceiving part is placed, is beyond our reach, but the condition of the nerve can be tested by applying the tuning fork to the middle of the forehead.

In health the fork should be heard in both ears with equal intensity. If, then, it is heard well in both ears the fault cannot lie with the auditory nerve, and the cause of the deafness must be sought for in the sound conducting part (the external and middle ear). In cases where the fault lies in this part of the organ, then, curiously enough, the tuning fork is heard best in the deafer ear.

External Ear and Membrana Tympani.—This part may be viewed by the unaided eye, by the mirror alone, by the mirror and speculum, and tested by the tuning fork. In examining the membrane any change of colour can be noted, whether it is red, or has lost its glossy appearance ; also whether it is concave and shows more clearly the various processes of bone in relation with it, from deficient internal pressure, or whether it bulges outwards from accumulation of fluids in the tympanic cavity, from obstruction in the Eustachian tube, or the results of inflammation. Also whether it is moveable as by Valsalva's method, or perforated, or entirely or partially hidden by wax.

Middle Ear and Eustachian Tube.—Much information can be gathered from the examination of the membrana tympani as to the condition of the middle ear. As it is transparent one may be able to see fluid in the middle ear through it. Also note whether it is thickened from fibrous changes in the middle ear, convex from accumulations in that cavity, or concave from an obstruction in the Eustachian tube whereby the air has become rarefied, or absorbed. The other avenue of information as to its condition is to examine the throat, as disease of the middle ear often begins in the throat and passes upwards along the Eustachian

tube to that cavity. Further, obstruction of the tube is very often due to hypertrophy of the pharyngeal tonsils *(adenoid vegetations of the nasopharynx)* blocking its orifice. Then, by some of the means already described, the Surgeon should examine whether the tube is patent or not.

Chronic suppuration of the middle ear is usually caused by inflammation spreading up from the throat *(naso-pharyngeal catarrh)*, and a large number of cases usually date their commencement from an attack of measles or scarlet fever—probably again from the inflammation spreading up from the throat. This is the origin of the 'running ear,' and when examined the membrana tympani is usually found to be perforated. Besides perforation, other and more serious complications are apt to follow suppuration of the middle ear—such, for example, as inflammation of the mastoid cells, caries of the bone, facial paralysis, inflammation of the membranes of the brain, cerebral abscess, perforation of the internal carotid artery, thrombosis of the lateral sinus or internal jugular vein, and lastly, destruction of the chorda tympani nerve. To explain these phenomena one has only to keep in mind the relations of the tympanic cavity. On the *inner* wall lies the facial nerve, covered only by a thin crust of bone; and immediately beyond this wall lies the internal ear, hence inflammation and suppuration may be readily set up here, and may possibly reach the brain through the internal auditory meatus. On the *outer* wall the chorda tympani nerve lies in a fold of mucous membrane. The *roof* is very thin, and inflammation can readily pass through the bone to the dura mater and then to the brain itself, especially in young persons

where the sutures have not as yet solidified. Only a thin layer of bone separates the *floor* from the internal jugular vein; the mastoid cells communicate with the cavity, and are also in close relation with the lateral sinus; and, lastly, the internal carotid artery is only separated from the anterior wall by a thin plate of bone.

In **trephining the mastoid cells** a small-headed trephine should be used, and its point must be directed forwards and inwards. Probably a less complicated form of instrument, such as a gimlet or bradawl, is all that is required, and will be equally efficient in cases demanding this operation. In either case were the instrument directed at right angles to the mastoid process there is a danger of going too deeply and opening the lateral sinus and yet missing the object of the operation. After having made an opening it must be treated in the same way as any other suppurating cavity, viz., introduce a drainage tube through the mastoid cells into the tympanic cavity, and wash it out occasionally with some warm antiseptic fluid in both directions, from the external auditory meatus, and also from the drainage tube.

CHAPTER XXVIII.

HEAD AND NECK.

TRACHEOTOMY.

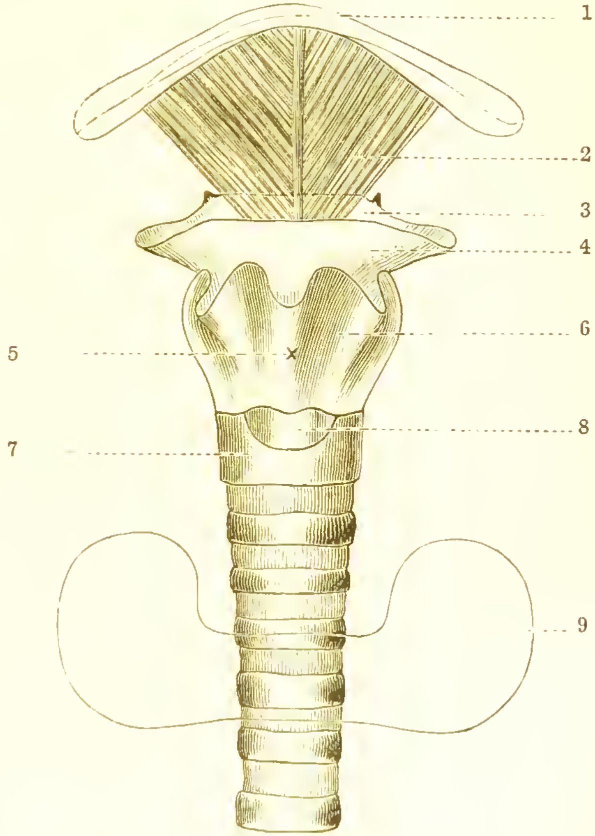
By this is meant the making of an opening in some part of the trachea. **Laryngotomy**—when the opening is made in the crico-thyroid membrane—usually by a single thrust; **Tracheotomy**—when the opening is made through some part of the trachea itself, either above or below the isthmus of the thyroid body; and hence we have the *high* and the *low* operations. **Laryngo-tracheotomy.**—In this operation the opening is made through the crico-thyroid membrane, cricoid cartilage, and upper rings of the trachea. The opening may be temporary or permanent. A *temporary* opening may be required for (1) obstructive œdema glottidis; (2) acute laryngitis; (3) spasms from pressure on, or irritation of, the recurrent laryngeal nerve; (4) emphysema of the loose connective tissue of the neck, as from a pen-knife wound; (5) scalds of rima, by boiling water or caustic fluid; (6) foreign bodies in the air passages; (7) masses of food in the gullet; (8) croup; (9) diphtheria. In diphtheria the obstruction is always at the chink of the glottis, but in croup it is in the trachea and bronchi as well. A *permanent* opening may be required for (1) chronic diseases of the larynx, resulting in thickening of the mucous membrane,

abscesses, necrosis of cartilages, &c.; (2) polypi of the larynx. Some surgeons doubt whether it should be opened in croup and diphtheria. In croup, the dangers are—(*a*) Obstruction to the larynx; (*b*) extension of the disease down to the lungs. So also in diphtheria we have similar dangers—(*a*) Obstruction to larynx and pharynx; (*b*) pulmonary inflammation, blood poisoning, and exhaustion. If the disease spreads downwards, opening the trachea may not save the patient's life; but it at least saves him from a very distressing kind of death, and there is a possibility (though it is not very great) that it may save his life. And we think, therefore, that even in croup and diphtheria opening the windpipe is a perfectly justifiable operation, so long as it gives temporary relief or affords the *least chance* of saving the patient's life. Besides, the operation of opening the windpipe is not meant to *cure the disease* but only to get rid of the danger of immediate death from asphyxia, and to *rest* the larynx.

In the **middle line of the neck** we find the following structures (Fig. 44):—(1) Symphysis of the lower jaw; (2) central tendon of mylo-hyoid muscles; (3) body of the hyoid bone; (4) thyro-hyoid membrane; (5) thyroid cartilage; (6) crico-thyroid membrane and arteries; (7) cricoid cartilage, which can be distinguished from the rings of the trachea by its more resistant feel; opposite this cartilage, as already pointed out, is the 'carotid tubercle' of the sixth cervical vertebra, and opposite this point also is the usual situation for applying a ligature to the common carotid, above the omo-hyoid. (8) Two or three rings of the trachea; (9) isthmus of the thyroid body (usually

crossing about the third or fourth rings); (10) the trachea again. The level of the vocal cords corresponds to the middle of the anterior margin of the thyroid cartilage.

Fig. 44.



MIDDLE LINE OF NECK.

1. Lower jaw. 2. Mylo-hyoid muscles. 3. Hyoid bone. 4. Thyro-hyoid membrane. 5. Level of vocal cords. 6. Thyroid cartilage. 7. Cricoid cartilage. 8. Crico-thyroid membrane. 9. Lateral lobes and isthmus of the thyroid body.

Position of the Patient.—The shoulders are well raised by pillows; the head is thrown as far back as

practicable, and kept perfectly straight and steady by the wrists of an assistant standing at the patient's head. A small firm pad should be placed under the neck so as to throw the windpipe forward. This assistant is also to be provided with a blunt hook in each hand, by which he retracts the soft parts as they are divided, taking care not to displace them at all to one side of the middle line, which is more apt to happen when the hooks are confided to the care of *two* assistants. Another assistant is to stand opposite the Surgeon to sponge the wound and secure bleeding vessels with catch forceps (WELLS'S). A third may administer chloroform. By throwing the head well backwards the trachea is drawn up into the neck and so gives the Surgeon more room; further it helps to steady it—the mobility of the trachea being one of the difficulties of the operation. The first assistant must be specially cautioned to keep the head exactly straight and in the middle line, and at the same time to avoid squeezing the mouth or nostrils.

Instruments.—Scalpel, Spence's hernia director, a good supply of catch forceps, dissecting forceps, blunt hooks, a sharp hook to fix and draw forward the trachea, trachea tubes and tapes, trachea dilator, sponges, ligatures, scissors, &c. The Surgeon stands on the right side.

Incision.—In tracheotomy, begin the incision at the upper border of the cricoid cartilage for the high operation, but over the isthmus of the thyroid body for the low, and carry it downwards, *exactly in the middle line*, for 2 or $2\frac{1}{2}$ inches. By this incision, (1) skin, (2) fascia, (3) fatty tissue, are divided. On each side of the median line are the two anterior jugular veins,

which are very often connected by a transverse communicating branch: these must, if possible, be avoided. (4) Cut through the inter-muscular fascia connecting the edges of the sterno-hyoids and sterno-thyroids, and separate them with the handle of the scalpel; also turn aside the inferior thyroid veins and *thyroidea ima* artery (if present), and the isthmus of the thyroid body, and some loose cellular tissue will now be brought into view. After the deep fascia of the neck is divided the *blade* of the knife must be laid aside; after this use the handle of the knife or SPENCE'S hernia director. Turn aside this loose tissue with the point of the finger or the handle of the scalpel, and the trachea is then exposed, and may be opened (either above or below the isthmus of the thyroid body, as circumstances may determine) thus:—Transfix and draw it forward by a sharp hook inserted into the cricoid cartilage, and push in the point of the knife, the blade being held between the finger and the thumb half an inch from the point to avoid the risk of transfixing the œsophagus, with its *back* towards the sternum (this is done whether the operation be above or below the isthmus), and cut through three or four rings, and introduce the tube—taking care first that all bleeding has ceased, unless the bleeding be due to the semi asphyxiated state of the patient, when obviously the best means to stop it is to open the trachea as quickly as possible. In the high operation the fascia connecting the isthmus to the trachea can be divided and the isthmus depressed and held there by a blunt hook, in cases where it is necessary to increase the space. The opening in the trachea and the tissues covering it must correspond exactly, otherwise mucus and air will escape into the

cellular tissue, producing emphysema. When the opening is made the handle of the knife must be inserted flatwise and then turned at right angles, while the Surgeon turns away his head till the patient coughs and after this he puts in a trachea tube, while the handle of the knife causes the opening to gape. Some prefer to use a special trachea dilator. It is then to be fixed by means of a tape tied at one side.

The **Trachea Tube** must be of a size corresponding to the age of the patient: in children under eighteen months, a diameter of about one-sixth of an inch is said to be sufficient; from that age up to four years the diameter should be about a quarter of an inch. The inner tube should be loose and a little longer than the outer tube, so that it may be driven out by coughing should it happen to become blocked up, and still the patient can breathe through the outer tube. Were it shorter, or even the same length as the outer tube, then, in cases of block, removal of the inner tube would not relieve the patient as the outer sheath would still be plugged. The *outer* tube has often an opening on its upper and convex surface, by means of which, when the inner tube is removed and the external opening closed, one can try whether the patient is prepared to breathe through his larynx again. In no case should there be an opening in this situation through *both* tubes, for then the patient would also breathe through his larynx, and keep it in a condition of unrest.

After Treatment.—The edges of the wound are approximated by strips of plaster or left entirely open. The patient must be surrounded by a warm moist atmosphere, and yet be supplied with plenty of fresh air; a careful nurse must be provided, whose duty it is to

look after the tube and wound, keeping it clear and covered with warm moist gauze. The causes of death after this operation are—(1) the disease necessitating the operation; (2) interlobular suppurative pneumonia from blood being inhaled at the moment the trachea was opened; (3) bronchitis from the inhalation of cold air, as the warming apparatus provided, by nature (the nose), is out of use for the present, and its place must therefore be filled by artificial means, such as the bronchitis kettle, warm moist gauze, &c.

RELATIONS OF THE TRACHEA.

The trachea extends from the lower border of the cricoid cartilage (or opposite the sixth cervical vertebra) to the body of the fourth dorsal vertebra where it divides into the two bronchi. It is usually said to extend from the fifth cervical to the third dorsal vertebra; but in the above numbers I have followed the teaching of the Edinburgh School. Its position varies with the position of the head — flexed or extended. The larynx and upper part of the trachea are also raised during deglutition, and during inspiration its length in the neck is diminished, because the upper margin of the thorax is raised. These changes of position are readily admitted because of the fibro-elastic membrane, which forms the basework of the trachea, and in which the cartilaginous rings are embedded. The movements taking place during deglutition are useful in sharply diagnosing all tumours connected with the trachea, *e.g.*, goitre; the patient is directed to swallow, when, if the tumour is connected with the trachea, it will rise with it during deglutition In the neck the trachea occupies the middle line, lying

in front of the œsophagus and vertebral column. In *front* of it we find the sterno-hyoid, sterno-thyroid, and deep cervical fascia, isthmus of the thyroid body, and the inferior thyroid veins, and the thyroidea ima artery, if it exists. At the *sides* we find the common carotid arteries, the lateral lobes of the thyroid body, inferior thyroid arteries, and the recurrent laryngeal nerves. In the **thorax**—In *front*, the upper part of the sternum, and the origin of the sterno-hyoid, and sterno-thyroid muscles, the remains of the thymus gland, left innominate vein, transverse part of the arch of the aorta with its branches. *Behind* is the œsophagus; on the *right* side the pleura and right vagus, and on the *left* side the pleura, left vagus, left recurrent laryngeal nerve, and left common carotid artery. The **length** of the trachea is about four and a half inches, and its **diameter** is about three-quarters of an inch. The *right* bronchus is shorter, wider, and more horizontal in its course; the *left* is longer, narrower, and more oblique in direction. It is usually said that foreign bodies for these reasons are more apt to pass into the left bronchus; but the larger size of the opening of the right bronchus, and the fact that therefore the septum is to the left of the middle line would seem to indicate that foreign bodies would more readily find their way into the right bronchus.

NOTE.—(1) If the incision is not exactly in the middle line, it will be difficult to keep the tube in its place; and besides, the carotid arteries might be injured. (2) Above the isthmus the trachea is quite superficial, and, as a rule, has no veins of consequence in front, except a communication between the superior thyroids; where the isthmus crosses (about the third or fourth

rings), there is usually a plexus of veins, besides the isthmus itself; below the isthmus, the trachea is more deeply placed, being covered, in addition to the superficial structures, by the sterno-hyoid and sterno-thyroid muscles, the large inferior thyroid veins, and sometimes by a special arterial branch to the thyroid body—the 'thyroidea ima.' (3) In stout, short-necked persons, the lower part of the trachea is more deeply placed. The chief difficulties of the *low* operation are:—(1) The trachea is deeper, as it gradually recedes from the surface as it passes downwards; (2) the inferior thyroid veins and the anterior jugulars, with a cross branch between them are in the way; (3) the danger to the isthmus is greater, because we must cut *towards* it, in order to avoid the important structures behind the upper part of the sternum; (4) the thymus body may be in front of this part; (5) the occasional presence of the 'thyroidea ima;' (6) the left innominate vein may take an unusually high course, and is all the more likely to be in the way when the head is thrown back.

TRACHEOTOMY IN CHILDREN.

Here the relations of the parts are somewhat altered. The neck is shorter; 'but, relatively, the space is greater between the isthmus of the thyroid body and the top of the sternum, so that the cervical part of the trachea is longer than in the adult.'—(SPENCE). But in the child the trachea is smaller, more deeply placed, and more moveable than in the adult; also, the danger from hæmorrhage is greater, on account of the large size of the venous plexus in connection with the thyroid body. There is more subcutaneous fat too; and the carotids are in closer relation to the trachea, so

that a *slight* deviation from the middle line may wound one or other of these important arteries. The presence and large size of the thymus body in the child will also complicate the operation.

A small hard pillow is placed under the neck, and the episternal notch is taken as the guide, the incision being a finger's breadth above this. It is very important to keep both the head and the incision exactly in the middle *line*. According to Dr SYMINGTON the usual position of the larynx in relation to the vertebral column in the new born child is from the lower border of the atlas to the middle of the fourth cervical vertebra; in the adult it extends from the middle of the third cervical to the lower border of the sixth cervical. He does not believe that this high position is due to its relatively small size, as often stated; and he further believes that its downward movement is caused by the growth of the facial portion of the skull.

Tracheotomy is the operation for children. In the child the crico-thyroid space is too small to allow of the introduction of a tube of sufficient calibre to support life, and therefore tracheotomy is to be preferred.

LARYNGOTOMY.

The crico-thyroid membrane is quite superficial, and may be felt as a slight depression about one inch below the 'pomum Adami.' If the case is urgent, open by plunging in the knife at once: if not, we may take the matter more coolly. Over the space make a vertical incision in the middle line through the skin, about an inch in length, and then make a *cross* cut through the membrane. The only danger likely to arise is hæmorrhage from the small arteries which cross and anastomose

in front of the membrane (the crico-thyroid branches of superior laryngeals). They are seldom a source of trouble; and by making a *cross* incision they are not likely to be wounded. Cases, however, are on record where serious and even fatal hæmorrhage occured from these vessels; I have myself seen a subject in the dissecting room where a trunk as large as the radial artery crossed in front of the crico-thyroid membrane. **Laryngotomy** is to be preferred in the adult because:—(1) The opening is quite as good as in the trachea; (2) it is far safer, from the simple anatomy of the parts; (3) it is more quickly performed; (4) diseases which necessitate the operation in the adult have little tendency to spread downwards. It should be used as a rule in the adult male; it is best in cases of foreign bodies impacted in the larynx, limited chronic disease, as syphilitic ulceration, acute or chronic œdema glottidis, tumours of the larynx, preliminary to other operations about the head and face, where there is danger of blood passing down the trachea, spasm of the muscles of the larynx from reflex irritation, as in cases of aortic aneurism. But in cases of foreign bodies in the trachea, bronchi, or pharynx, tracheotomy should be performed.

Œdema Glottidis.—Œdematous infiltration about the larynx is chiefly confined to the sub-mucous areolar tissue round the epiglottis, aryteno-epiglottidean folds, and arytenoid cartilages. In these situations the sub-mucous tissue is very loose and freely movable, and readily becomes infiltrated and distended with serous effusion—so much so, as almost to occlude the rima glottidis. But this effusion and distension never extends below the true vocal cords, being limited at this point by the direct adhesion of the mucous membrane to the

fibrous tissue forming the cords, without the intervention of any sub-mucous coat.

CUT THROAT.

This may be (1) **above the hyoid bone,** when probably the following structures will be divided:—Skin and superficial fascia, radicles of the anterior jugular veins, deep fascia, anterior belly of the digastric muscles, mylo-hyoid, genio-hyoid, genio-hyoglossus, and probably right through into the floor of the mouth. Lingual artery, branches of the facial vessels, hypoglossal nerve, lingual nerve, and sub-maxillary gland. (2) **Below the hyoid bone.**—Integumentary structures, anterior jugular veins, facial and superior thyroid veins, sterno-thyroid, thyro-hyoid, and omo-hyoid muscles, thyro-hyoid membrane, inferior constrictor, internal branch of superior laryngeal nerve, superior laryngeal artery, and probably also the superior thyroid and lingual arteries too. The cut may open into the pharynx. (3) **Below the box of the larynx,** a rare form: the integuments, anterior jugular veins, sterno-hyoid, sterno-thyroid, omo-hyoid, possibly the sterno-mastoid, thyroid gland, superior and inferior thyroid arteries, the thyroid veins, especially the inferior, recurrent laryngeal nerves, trachea, and œsophagus, and prevertebral muscles.

In most cases the head is thrown so well back that the gash may extend right down to the vertebræ without injuring the carotid arteries, and therefore without causing immediate death; the lower down the cut is made, the more likely are the vessels to be opened. The **dangers** are (1) great and fatal hæmorrhage at once; (2) less rapid death by being gradually choked by the blood inhaled into the windpipe; later (3)

pneumonia from the entrance of blood into the bronchi; (4) bronchitis, from entrance of cold air, &c.

OPERATIONS ON THE ŒSOPHAGUS.

Relations in Neck.—It is about nine inches in length, and extends from the lower border of the cricoid cartilage to the stomach—about the level of the ninth dorsal vertebra. In *front* is the trachea, and the thyroid gland and thoracic duct low down; *behind* it rests against the vertebræ following the curves of the column, and also rests on the longus colli muscle; on *each side* are the common carotid arteries, thyroid gland, recurrent laryngeal nerves, and inferior laryngeal arteries. The narrowest parts of the tube are (*a*) at its commencement, and (*b*) next where it passes through the diaphragm. **Œsophagotomy** (opening the œsophagus for the purpose of removing a foreign body—a temporary opening). **Œsophagostomy** (opening the œsophagus in order to make a mouth there to feed the patient—a permanent opening). The position of the patient is the same as for ligature of the common carotid. **Instruments.**—Scalpels, directors, retractors (broad copper), blunt hooks, catch forceps, dissecting forceps, a bulbous headed bougie, sponges, needles, ligatures, &c.

Make an **incision** about four inches in length along the anterior border of the *left* sterno-mastoid (as the œsophagus in the neck lies to the left of the middle line), beginning a little below the level of the upper border of the thyroid cartilage. The incision is almost the same as that necessary in ligature of the left common carotid, low down, but a little nearer the middle line. Divide the skin, platysma, and fascia, and draw aside the sterno-mastoid, or divide its sternal head. Carefully

dissect down, with the handle of the knife, or fingers, between the carotid sheath, trachea, and larynx. Draw the sterno-hyoid and sterno-thyroid muscles towards the middle line, the thyroid body upwards, and if the omo-hyoid be in the way, divide it. Great care is now necessary to avoid wounding the thyroid arteries—especially the inferior—passing to the lower angle of the thyroid body behind the carotid sheath; also to avoid injuring the left recurrent laryngeal nerve, which lies between the œsophagus and trachea. The œsophagus being exposed, pass a bulbous bougie, or probang, through the mouth into it, and cause its walls to project: this is made to serve as a guide for the necessary incision; otherwise the air passages might be cut into.

After Treatment.—The patient must be fed through a narrow tube (No. 10 Catheter) passed through the mouth, past the wound in the œsophagus, for a few days till granulations form on the sides of the wound, and close up the intermuscular cellular planes. No sutures are required for the wound in the œsophagus, or for the external wound either, though after the granulations have formed it may be stitched up if thought necessary. The **danger** of this operation is the risk of setting up cellulitis in the extensive intermuscular cellular planes of the neck. As the wound in the œsophagus is parallel with its long axis, there is no risk of subsequent stricture. (The different effects of transverse and longitudinal division of tubes, in relation to stricture, was first pointed out by Dr John Duncan some years ago.)

THE PHARYNX.

This is a membrano-muscular sac, about four and-a-half inches in length, extending from the under surface of the skull to the cricoid cartilage. *Behind* it is connected by loose areolar tissue, with the vertebræ and the longus colli, and anterior recti muscles. It is connected above to the base of the skull, being attached to the internal pterygoid plate, the pterygo-maxillary ligament, the lower jaw, tongue, hyoid bone, larynx, and styloid process. In relation to its outer surface, we find the common and internal carotid arteries, the internal jugular veins, the glosso-pharyngeal, the spinal accessory, the vagus, and the ninth cranial nerves, and the sympathetic trunks. It has **seven openings**—the two posterior nares, the two Eustachian tubes, the mouth, larynx, and œsophagus.

Parotid Duct (Stenson's).—Its course is indicated by a line drawn from the external auditory meatus to a little below the nostril. Above it, is the transverse facial artery, and below it are some branches of the facial nerve. It perforates the cheek obliquely, or almost at right angles to its former course, opposite the second molar tooth of the upper jaw. It is necessary to remember its course, as it may be divided in wounds or operations about the face, and give rise to salivary fistula.

Division of the Fifth Nerve on the Face.—The supra-orbital notch or foramen is situated about the junction of the inner with the middle third of the supra-orbital margin. From this point a perpendicular line drawn, with a slight inclination outwards, so as to cross the interval between the two bicuspid teeth,

passes over the infra-orbital and mental foramina.—(HOLDEN).

Before, however, resorting to such extreme measures for the relief of neuralgia, &c., it is a good plan always to look the mouth, and direct the patient to get rid of all rotten teeth, which are perhaps the most common cause of neuralgia.

Division of the Lingual Nerve *('Gustatory').*—This being the nerve of common sensation to the anterior two-thirds of the tongue, its division has been practised inside the mouth, with the view of relieving the pain of cancerous ulcers of that organ, and diminishing the profuse salivation in cases where operation is out of the question. It is a branch of the third division of the fifth, and opposite the second molar tooth, it is simply covered by the mucous membrane of the floor of the mouth. 1. **Hilton's Plan.**—Is to divide the nerve opposite the second molar tooth, where it can be raised by a blunt hook, seen, and divided. But in cases where the disease has involved the floor of the mouth this plan is inapplicable, and, further, the guides to the spot in question are not quite definite. 2. **Mr Lucas** gags the patient and then passes a strong silk ligature through the tip of the tongue, and pulls it forwards, and to the opposite side to that on which he is to divide the nerve. In this way the nerve is seen standing out as a firm cord, extending from the angle of the jaw, along the side of the tongue. A sharp hook is then passed beneath it, and then the mucous membrane divided over it, and the nerve then cut, stretched, or a portion removed as the Surgeon may think fit. 3. **Moore's Plan.**—He divides the nerve further back than **Mr Hilton**, and

takes as his guide the last molar tooth. **Guide.**—A line drawn from the middle of the crown of the last molar tooth to the angle of the jaw. This line will cross it in the exact place where it should be cut. It lies about half an inch from the tooth between it and the anterior pillar of the fauces, parallel with, but behind and below the prominent alveolar ridge on the inner side of the body, and ascending ramus of the lower jaw. Enter the knife about three quarters of an inch behind and below the last molar tooth, and cut down to the bone, and the nerve is certain to be divided.

Removal of the Tonsils.—The tonsils are situated between the anterior and posterior pillars of the fauces, and, in health, do not project beyond the level of these arches. If they are much enlarged they interfere with respiration, and must be removed; this may be done by a probe-pointed bistoury. Cut downwards and inwards, and on no account turn the edge of the knife outwards, lest the internal carotid artery, and the ascending pharyngeal branch of the external carotid, be injured, there being nothing covering these vessels at this point except the pharyngeal aponeurosis and the superior constrictor of the pharynx.

Bursæ in the neck.—(1) There is one in front of the 'pomum Adami;' (2) another between the thyroid cartilage and the posterior surface of the hyoid bone; (3) and one between the muscles of the tongue. The third may not be present; either of the bursæ may occasionally be enlarged.

Dislocation of the Lower Jaw.—This is perhaps the most common *muscular* dislocation. It is usually caused by some sudden exertion on the part of the

patient, or spasmodic action of the depressors of the jaw, as in gaping, fits of laughter, attempting to take too large a bite, &c. It may be—(1) unilateral or incomplete; (2) bilateral or complete, according as one or both of the condyles are displaced. When the mouth is opened the condyle with the inter-articular fibro-cartilage glide forward on to the eminentia articularis; but if this be continued too far, and if, at the same time, the *external pterygoid* muscle contracts forcibly, the condyle slips forward into the zygomatic fossa. In this way a dislocation is produced. NÉLATON believes that it is caused by the coronoid process locking against the malar bone; but Mr HEATH simply attributes it to excessive muscular action. Probably during the wide gape some of the sensory twigs of the fifth are squeezed, and the stimulus thus communicated to the nerve may reflexely cause contraction of the muscles that pull forward and depress the jaw. It is most likely to be the auriculo-temporal nerve that is irritated in the same way, for example, as in ear yawning. The capsular ligament is not ruptured, and reduction is, as a rule, easily accomplished by disengaging the condyle, by pressing down with the thumbs, guarded by a towel, in the mouth behind the last molar tooth, while at the same time the chin is pushed upwards and backwards by the fingers.

Venesection from External Jugular.—This may be useful in cases of croup in young children, apoplexy in adults, or in venous congestion of the head or chest. The course of the vein may be indicated by a line drawn from a point midway between the mastoid process and the angle of the jaw to the middle of the clavicle. The vein is crossed obliquely by the fibres of

the platysma, their relative positions being represented very nearly by the letter X. To secure a good flow, the cut in the vein must be oblique, because if longitudinal the edges would not gape. But the external jugular must not be opened by a single oblique thrust at once, because the cut would then be parallel to the fibres of the platysma, which by their contraction would prevent the free exit of the blood, and might give rise to extravasation and thrombus. It should be opened about the middle of the neck while it lies on the sterno-mastoid, because at this point it is most superficial and more firmly fixed. (1) Compress the vein at the lower part of the neck to make it 'rise,' and also to prevent the entrance of air; this is best accomplished by a thick compress over the lower part of the vein, held in position by a bandage passed around the neck and under the opposite axilla. (2) Make an incision in the skin obliquely to the course of the vein. (3) Divide the fibres of the platysma transversely. (4) Open the vein by an oblique incision (exactly the same direction as that made in the skin, but rather smaller). To stop the bleeding, fix a pad of lint over the wound by strips of adhesive plaster, the whole being held in position by a domet bandage and plenty of cotton wool.

Arteriotomy from Anterior Branch of Temporal.—This may be necessary in affections of the eye, *e.g.*, in iritis when there is great pain. Its pulsations can be felt about one inch and a quarter behind the external angular process of the frontal bone. Compress on the *distal* side of the intended opening to fill and distend the vessel (veins should be compressed on the *proximal* side). Expose it, by cutting through the superficial structures and the dense fascia covering it, and then

make an oblique opening into it. To stop the flow, cut the artery completely through, when its coats will, as a rule, contract and retract sufficiently to stop the bleeding; if not, secure by acupressure, or ligature the cut ends. A pad is then to be placed over the wound and held in position by a stella bandage.

HARE LIP AND CLEFT PALATE.

To understand these conditions it will be necessary to say a few words as to their development. Between the first visceral arch and the frontal protuberance of the embryo is situated the buccal depression, which in time becomes the mouth. The frontal protuberance sends down a process from which is developed the vomer, the triangular cartilage, and soft coverings of the nose, the præ-maxillary bones with their contained incisor teeth, and the central part of the upper lip. The first visceral arch divides at its anterior extremity into a superior and an inferior maxillary process. The inferior processes on each side unite at a very early period to form the lower jaw, and the superior maxillary processes and the frontal process should also unite together, probably between the sixth and twelfth weeks of fœtal life, to form the upper lip and complete alveolar ridge. Any arrest of development during this period will result in more or less complete hare lip, and as the frontal process forms the centre parts of the upper lip and jaw, it is easy to see that the gap must necessarily be at one or other side, or on both sides, as the case may be. In regard to the palate, at the sixth week of fœtal life the mouth, nose, and pharynx form one large undivided space. Soon, after this, however, a process begins to grow inwards from the alveolar

ridge on each side, which ultimately form the hard and soft palates, except the part in front of the oblique sutures formed by the præmaxillary bones, which are developed from the frontal protuberance. The palate should be completed about the ninth week. In the lips and palate, therefore, the line of union is Y-shaped, the upper diverging arms representing the præmaxillary sutures, while the straight part represents the line of union between the two sides of the palate. Non-union may occur along the whole of this line, giving the most extreme degree of combined hare lip and cleft palate, in which case the part of the frontal process which should have formed the central part of the upper lip and alveolus is attached to, or rather has not separated from, the tip of the nose. It may vary from this, the most extreme form, to a mere slit or dent in one lip, usually the left. In operating for hare lip, the follow-structures will be divided from without inwards:—(1) skin; (2) superficial fascia; (3) orbicularis oris muscle; (4) coronary vessels; (5) mucous glands and mucous membrane. Note the position of the vessels, between the muscle and the mucous membrane. In operating the chief points to attend to are—(1) to pare the edges freely, so as to give a raw surface with sharp corners and not rounded edges; (2) to loosen the mucous membrane between the lip and the gum freely to avoid tension on the sutures, and obviate the necessity of such things as trusses, &c.; (3) prevent any nick or dent in the lip afterwards. For this purpose some are content to trust to free paring of the edges and loosening of the mucous membrane and neat apposition with sutures; others make the raw edges concave from above downwards. NÉLATON, in suitable cases, does not quite

pare off the parts from the side of the cleft, but leaves them attached to the free edge of the lip, and brings them down so as to make a diamond-shaped wound instead of the usual triangular cleft. The sides are then brought together, and instead of a depression there is a distinct projection at the site of the former deficiency. In other cases only one of the tags is left, which is then brought across the cleft and stitched to the opposite side. The best **age** for operating will depend on the strength and health of the patient, unless the want of strength is due to the condition in question; it may be done from a few weeks after birth up to the third or fifth month, usually before the first dentition. If not done by that time it must be left till after the completion of the first dentition—after the second year. The **instruments required** are:—A well-worn and very sharp scalpel, several pairs of Wells's forceps, dissecting forceps, hare-lip pins, wire-cutting nippers, silk sutures for the mucous membrane, horse hair sutures for the skin, silver wire for deep sutures, adhesive plaster, catgut ligatures, flexible collodion, scissors, Hainsby's 'truss,' sponges—large and small, some fastened on small sticks, or on special sponge holders, or else grasped by a pair of Péan's forceps, bone pliers, and a large sheet in which to wrap and hold the child.

Staphyloraphy, or operations for the cure of clefts in the soft palate. In this case it is of great importance to avoid tension on the stitches as otherwise they are apt to cut their way out. In cases where hare lip and cleft palate co-exist then the lip must be cured first, and very often after this the palate improves wonderfully. The operation should be done, if possible, before the child

begins to learn to speak. As a child with cleft palate cannot suck, it will be necessary to adopt some artificial means of feeding it. In cases where the cleft in the hard palate is very wide, cure by operation is out of the question, the case being one for the dentist. In less marked cases we may adopt LANGENBECK'S plan of levering up the muco-periosteal tissue with an elevator and making the flaps from the two sides meet across the gap. Before doing so, however, it is necessary to make liberating incisions along the inner side of the alveolus, taking care that they do not go back beyond the last molar tooth or forward beyond the canine tooth, lest the anterior and posterior palatine vessels be divided, on which the nutrition of the periosteal flap depends. In very bad cases an attempt may be made to shift bones and all (FERGUSSON). The term **Uranoplasty** is sometimes applied to operations for the cure of fissures in the hard palate; the student must remember that the term has got nothing to do with the urine, or with plastic operations on the penis or urethra.

For the **soft palate**—(1) Liberating lateral incisions may be simply made with the scissors in the way recommended by Mr BRYANT. (2) FERGUSSON'S plan of dividing the perpendicular part of the levator palati midway between the Eustachian tube and the hamular process, by means of a rectangular knife passed through the cleft in the palate. (3) POLLOCK'S method of dividing both the tensor and the levator by means of a knife passed through the soft palate close to the hamular process. It may also be necessary to divide the palato-glossus and the palato-pharyngeus muscles (the anterior and posterior pillars of the fauces), which can easily be done by a touch of the knife.

In this operation the following **structures, composing the soft palate,** are divided from before backwards:—

1. Mucous membrane.
2. Submucous tissue, glands, vessels, &c.
3. Palato-glossus muscle.
4. Aponeurosis of the tensor palati.
5. Palato-pharyngeus, anterior fasciculus.
6. Levator palati and azygos uvulæ muscles.
7. Palato-pharyngeus, posterior fasciculus.
8. Submucous tissue, glands, vessels, &c.
9. Mucous membrane.

To assist the memory notice that they run in pairs, the first and ninth, the second and eighth, and so on.

The **instruments required** are—A long-handled well-worn scalpel, Fergusson's rectangular knife, curved scissors, forceps to grasp the palate while paring it, special needles on handles for passing the sutures, gag, periosteum elevators, chisel, silk sutures, catgut ligatures, dissecting forceps, silver wire, sponges on sticks, or special sponge holders, or grasped by Péan's forceps, chloroform, &c.

CHAPTER XXIX.

WOUNDS OF THE SCALP.

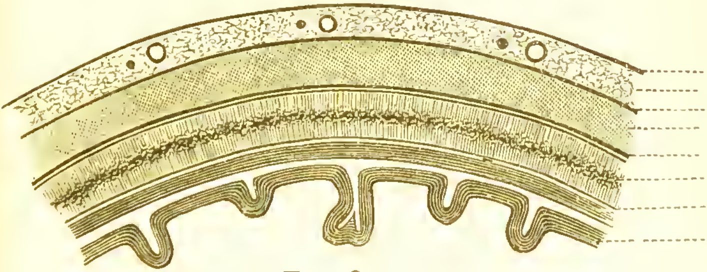
These, however slight, should be watched very carefully, because of the close anatomical relations that exist between the internal and the external structures of the cranium, and the possibility, therefore, of the effects of the injury implicating the brain and its membranes; and all the more so when we bear in mind that, from the nature of the textures wounded, they are far more likely to be followed by erysipelatous inflammation than wounds in other parts of the body. The chief anatomical peculiarities of the scalp are—(1) The great amount of dense fibrous tissue that enters into its formation. (2) Its great vascularity, and, consequently, (3) its great vital activity. (4) Its vascular connections with the cranial bones and dura mater; this is especially the case with the cellular tissue on its deep surface, which is largely permeated by blood vessels, which enter the bones and communicate in the diploë with branches from the dura mater. At several places also large vessels pass directly through from the scalp or face, and communicate with the various sinuses and arteries within the cranium, *e.g.*, at the occiput the meningeal branches of the occipital artery anastomose with those of the vertebral; behind the ear a large vein passes through the mastoid foramen to the lateral

sinus; on the vertex another vein passes through the parietal foramen to the superior longitudinal sinus; on the face, at the inner angle of the orbit, the angular artery and vein anastomose, with the nasal branch of the ophthalmic artery and ophthalmic vein, and other branches of the ophthalmic artery anastomose with the middle meningeal. There are other communications through the anterior and posterior condyloid foramina, foramen ovale, foramen lacerum posticum, and most other openings at the base. Leeches may be applied at many of these parts to relieve congestion of the brain. Another important communication exists between the facial vein and the cavernous sinus (besides the one through the orbit) through the pterygoid plexus, a plexus formed by the middle meningeal vein, deep temporals, pterygoids, masseteric, buccal and inferior dental, and which is situated between the external pterygoid and temporal muscles, and partly between the two pterygoids themselves, and is connected on the one hand with the facial vein and on the other with the cavernous sinus through the foramen Vesalii. These communications between the external vessels, and those of the diploë of the bone, and also with the sinuses of the dura mater, explain the danger of erysipelas and other inflammatory condition such as carbuncle, attacking the face and scalp, especially in cases where there is or has been an open wound, and probably therefore septic matters have gained an entrance. The inflammation causes thrombosis in some of the venous trunks, especially the facial, these thrombi are probably, or soon become, septic, break down and give origin to minute septic emboli, which spread widely and give rise to all the

signs of pyæmia. Or the inflammation may pass directly backwards along the veins to the cerebral sinuses.

Between the grey matter on the surface of the brain and the outside, the following structures intervene (Fig. 45):—(*a*) The scalp, consisting of—(1) The skin; (2) the superficial fascia, with fatty tissue and the arteries and nerves of the scalp; (3) the central tendon of the occipito-frontalis. Then follows (4) a layer of loose cellular tissue over which the above three layers, which are really *one*, can be moved

Fig. 45.



THE SCALP.

1. The skin. 2. The superficial fascia, with vessels and nerves. 3. Tendon of occipito-frontalis. 4. Layer of loose cellular tissue—'dangerous area.' 5. Pericranium. 6. The bone. 7. Dura mater. 8. Brain.

freely; this is often called the 'dangerous area' of the scalp, from the ease with which suppurative processes are set up in wounds, extending to this layer, and which then spread in all directions. (*b*) The bone—This may be regarded as consisting of (1) the pericranial aponeurosis, which is firmly attached to the 'sutural ligaments' at the various sutures, and therefore extravasation beneath it (as of blood, *Hæmatoma*, sometimes met with in new-born children) is limited to the bone over which it commenced; (2) outer table of

the skull; (3) the diploë, with its large venous trunks; (4) the inner table, characterised by its great brittleness *(lamina vitrea)*, and hence it may be fractured without any fracture of the external table, and is usually more extensively broken than the external. (*c*) **The Brain**—including (1) the dura mater; (2) the subdural space; (3) the curtain-like arachnoid; (4) the subarachnoid space, containing the cerebro-spinal fluid, upon which the brain floats; (5) the pia mater; (6) the brain substance proper.

Attachment of the Pericranial Aponeurosis.—It is *firmly* attached to the fat and fascia superficial to it, but only *very loosely* connected with the parts beneath by means of fine cellular tissue. *Posteriorly* it is attached to the superior curved lines of the occipital bone; at the *sides* to the mastoid process, attolens and attrahens aurem, and zygoma; in *front*, it is blended with the corrugator supercilii, orbicularis palpebrarum, and pyramidalis nasi.

In bruises of the scalp, extravasation may take place either *into* or *under* the aponeurosis. In suppuration *beneath* it the pus gravitates to the most dependent parts, until arrested by its attachments; and, according to its position, may form a bag bulging over the orbits, the root of the nose, or above the zygoma, or passing down towards the neck behind. Sometimes it spreads over the whole extent of the head, and yet the scalp does not die because it carries its blood supply with it. Extravasation *into* the scalp texture may simulate a depressed fracture. Owing to the density of the scalp texture, the extravasation is limited, and forms a circumscribed flattened swelling; the edges feel extremely hard from the

coagulation of the blood in the interstitial textures of the scalp, while the centre, where the blood is not yet coagulated, is soft, and gives rise to the supposition that there is a depressed fracture. By firm, downward pressure, however, the unbroken cranial bone may be detected beneath, and besides, the hard edge is not sharp, but *rounded*.

The pericranium stands in the place of periosteum to the bones of the skull; but even though it is removed over a considerable area the bone does not necessarily die, probably from the nourishment derived from the diploë and dura mater. Further, in cases of necrosis of the bones, it is doubtful whether the pericranium ever forms new bone. The dura mater acts as periosteum on the other side; it is very firmly attached to the base of the skull, but much less firmly to the vault, and hence it is readily separated in this position by a blow or blood extravasation.

Meningeal Arteries.—(1) In the anterior fossa of the skull we have small branches from the anterior and posterior ethmoidal arteries. (2) In the middle fossa we have—(*a*) the middle meningeal entering through the foramen spinosum; (*b*) the small meningeal entering through the foramen ovale; (*c*) meningeal branch from the ascending pharyngeal entering through the foramen lacerum medius. (3) In the posterior fossa we have small branches from the occipital and vertebral arteries.

The largest and most important of these is the middle meningeal. It is liable to be ruptured by blows on the temple, producing fracture of the parietal or temporal bones, or great wing of the sphenoid—more especially in the case of the parietal and sphenoid, as it enters the skull through the foramen in the spinous process of the

sphenoid, and frequently traverses for a short distance a bony canal *in* the anterior inferior angle of the parietal bone. But the various sinuses at the base of the cranium are also liable to be ruptured, *e.g.*, hæmorrhage into the orbit and eyelid points to rupture of the cavernous sinuses; bleeding from the ear, followed by the discharge of a clear fluid, may be due to fracture of the petrous part of the temporal bone, with laceration of some of the sinuses in that neighbourhood (inferior or superior petrosals and lateral).

The position of the middle meningeal artery—about an inch and a half behind the external angular process of the frontal bone, and about the same distance above the zygoma—as well as the structures cut through to reach it, have been already given *(see Ligature of the Middle Meningeal*, p. 90*)*.

THE PAROTID GLAND.

This gland fills up the hollow between the mastoid process and the sterno-mastoid muscle behind, and the ascending ramus of the lower jaw in front. **Boundaries.**—*Above* it extends as high as the zygomatic process: *below* it is bounded by a line passing from the angle of the lower jaw to the anterior border of the sterno-mastoid muscle; *behind* by the external auditory meatus, pinna, mastoid process, and sterno-mastoid muscle; *anteriorly* it stretches over the masseter muscle, and from this part the duct emerges. The *deep surface* of the gland extends to the styloid process, passes beneath the mastoid process and sterno-mastoid muscle; it also fills up the hollow behind and below the articulation of the lower jaw, and further, passes to the great vessels in this region.

Tumours and Abscesses of this gland give rise to

much pain because of the dense unyielding fibrous capsule of the gland, and, therefore, should be relieved early by incision (in the case of abscess), or excision (in the case of tumours). The relation of the gland to various important vessels and nerves must be kept in mind. (1) The external carotid enters the deep surface of the gland, and gives off in it the following branches:—(*a*) Occipital; (*b*) posterior auricular; (*c*) temporal; (*d*) internal maxillary. (2) Passing from the gland is the external jugular vein, formed in the gland by the union of—(*a*) Temporal; (*b*) internal maxillary; (*c*) posterior auricular; (*d*) transverse facial veins. (3) The auriculo-temporal nerve enters the gland at its lower and posterior part, and the facial nerve passes through the gland and leaves it by its upper, anterior, and lower borders. The order from the surface is—nerves, veins, arteries. But, further, the deep surface of the gland is in relation with the internal carotid artery, and internal jugular vein. In operations about the gland for the excision of tumours or the opening of an abscess, the knife should not be entered behind a line drawn from the condyle to the angle of the jaw, lest the external carotid artery should be injured; and, to avoid wounding the trunk of the facial nerve or the chief branches of the 'pes anserinus,' the incisions should be made as far as possible parallel with the main trunks—*i.e.*, the knife must be held horizontally, and the gland at the same time be drawn well forwards. The facial is the motor nerve of the muscles of expression, and its division gives rise to paralysis of these muscles, hence the importance of preserving it from injury. Abscesses, however, in this region are best opened in the way introduced by the late Mr HILTON: an incision is made through the skin

and deep fascia only, and then a director is pushed on into the cavity of the abscess; that the director has reached the abscess is indicated by the fact that the point is free, or else by the escape of pus along the groove. Then a pair of dressing forceps are passed along the director, closed, and when they have entered the cavity the director is taken out and the blades are then opened, and the instrument withdrawn. As elsewhere the opening must be dependent for the purposes of drainage.

TREPHINING.

This operation should not be performed over the course of the sinuses, nor in situations likely to wound the middle meningeal artery. A line drawn over the head from the root of the nose to the occipital protuberance indicates the course of the *superior longitudinal sinus;* another line drawn from the same protuberance to the external auditory meatus indicates the course of the *lateral sinus*, and about the middle of this line the pulsations of the occipital artery may be felt.—(HOLDEN.)

The position of the middle meningeal artery must also be avoided, unless trephining in this situation be indicated for special reasons.

Properly speaking, 'trephining' should only be applied to cases where a complete circle of bone is removed from the skull by the trephine, though it is usual to speak of elevating depressed fragments, removing small angles of bone with a Hey's saw, &c., as 'trephining.' 'Trepanning' is an operation seldom, if ever, performed now. In this the bone was removed by a trephine head worked in the same way as a

carpenter's boring brace. **Instruments.** — Scalpel, trephines, dissecting forceps, catch forceps, brush to clear away the sawdust, director, fine hypodermic syringe or Graefe's cataract knife, quill, Hey's saw, elevator the 'lenticular,' sponges, &c.

Cautions.—The chief points to be attended to are—(1) To avoid the course of sinuses and arteries; (2) to work the trephine very cautiously, as one can have no idea of the thickness of the skull, it may be very thin or very thick, or one side thick the other thin; the rule Mr CHIENE gives is, to trephine just as if the skull in question was the thinnest skull ever seen. (3) The pericranium must be preserved. The old way was to make a crucial incision through everything right down to the bone at once, and then turn back the flaps. At the present time a V or horse-shoe shaped incision is usually employed. (4) The circle of bone must be sawn completely through before it is removed, otherwise a sharp splinter is left on the inner edge which is difficult to remove, and which if not removed will set up inflammation of the membranes. The centre pin of the trephine is made to project, and fixed by the screw at one side for that purpose; it is then applied to the denuded bone, into which the centre-pin is at once pressed so that it may fix the trephine head till it has made a groove for itself. It is rotated alternately from right to left until the groove is sufficiently deep to hold the crown, when the centre pin is withdrawn. The groove is to be cleared out from time to time by a small brush and measured by a quill or probe to see if it is of the same depth all the way round. When the diploë is reached the sawdust will be tinged with blood, and then the operator must be specially cautious.

With the view of avoiding wound of the dura mater some operators recommend a conical-crowned trephine.

When to Trephine.—No exact rules can be laid down for all cases; each case must be judged on its own merits. The following rules (after Spence) may be taken as fairly typical and trustworthy:—(1) *At once* in all cases of distinct punctured fracture. In these cases the fracture is, of course, always compound, and we know that the inner table is much broken up probably into a number of loose, sharp-cornered fragments, which are *sure* to set up mischief if left, which will necessitate their removal later on and under less favourable conditions. The trephining in this case is *not* to relieve compression. (2) *At once* in cases of compound comminuted depressed fracture in the *adult*; not in cases of mere fissure with wounded scalp. In the *child* wait for symptoms. (3) In simple depressed fracture try other means first, and only trephine when the symptoms of compression are urgent and persistent. By following this plan we avoid unnecessarily transforming the simple into a compound fracture. (4) In compression due to extra-meningeal hæmorrhage, when its position can be diagnosed—by the existence of a fissured fracture over the course of the middle meningeal for example. (5) In compression due to suppuration, if the seat can be diagnosed, as from the previous existence of suppuration of the middle ear, or from the presence of Pott's 'puffy tumour,' or unhealthy state of a scalp wound or bone. (6) In cases of epilepsy or local paralysis, due to some local injury, such as a contusion; in these cases the existence of an old scar may guide. (7) In tumours of the brain, if their seat can be diagnosed.

EXCISION OF THE TONGUE.

This operation may be performed in several ways—(1) From the inside of the mouth, without any external incisions. (2) By incisions below the jaw (submental, or Regnoli's method). (3) By section of the lower lip and jaw (Sédillot's method). **Instruments required.**—Scalpel, a broad pointed pair of dissecting forceps, an extensive stock of Wells's or Péan's forceps, a gag, a bone drill, copper retractors, blunt hooks for ligature of lingual; tooth forceps for incisior teeth, in cases where the jaw is to be divided; a narrow bladed, moveable backed, saw; stout silk thread to pass through tip of tongue, copper or silver wire to suture the jaw, 'key' to tighten the same, wire cutting pliers, scissors of various kinds, (one pair curved and blunt pointed); ligatures of catgut and silk, solution of chloride of zinc, collodion to close incision after ligature of the lingual, small sponges on sticks, special sponge holders, or on Péan's forceps, Trendelenburg's trachea 'tampoon,' or some other means to prevent blood passing down to the lungs; instruments for tracheotomy; Higginson's syringe, lint, bandages, needles, chloroform, two strips of bandage to fasten round and separate the divided jaw.

1. **From the Inside of the Mouth.**—The patient is gagged and the tongue is secured with a piece of whip cord, and drawn well forwards and upwards. Then, by means of a strong curved pair of scissors, cut through —(*a*) frænum linguæ; (*b*) insertions of genio-hyoids; (*c*) insertions of genio-hyo-glossi muscles, and cut well back so as to set free the base of the tongue, dividing (*d*) the palato-glossus; then cut (*e*) the reflexion of the

mucous membrane of the floor of the mouth from the lower jaw. Free the base of the tongue with the fingers and draw it well forwards, and apply the wire écraseur and gradually remove the organ. If the anterior pillar of the fauces be in the way it may be cut across. If one half of the tongue is to be removed then two écraseur's must be used; or, better, after the base of the tongue is freed, then by means of a sharp pointed bistoury transfix the tongue at the posterior part, from below upwards; and then cut accurately along the middle line to the tip, and then apply the écraseur at the base of the half to be removed.

WHITEHEAD, of Manchester, removes the tongue through the mouth with the scissors alone. The patient is gagged as before, and the gag committed to the care of an assistant. Then a double ligature is passed through the tip of the tongue one inch from the tip, and given in charge to a second assistant who has to make steady traction upwards and outwards during the whole of the operation. The operator then divides all the attachments of the tongue to the jaw and pillars of the fauces with a pair of ordinary straight scissors. The muscles forming the base of the tongue are next to be cut across by a series of short snips of the scissors as far back as the safety of the epiglottis will permit. Bleeding vessels are now to be twisted or tied, and then a loop of silk is passed through the glosso-epiglottidean folds of mucous membrane as a means of drawing forward the floor of the mouth in the event of secondary hæmorrhage: this ligature may be removed on the second day. The structures divided are—(1) the mucous membrane; (2) genio-hyoids; (3) genio-hyo-glossi muscles; (4) part of the sub-maxillary gland

with vessels and duct, though the gland may be pushed aside; (5) palato-glossus muscle; (6) hyo-glossus; (7) stylo-glossus; (8) intrinsic muscles of tongue; (9) glosso-epiglottidean folds of mucous membrane; (10) lingual vessels; (11) lingual and chorda tympani nerves; (12) hypo-glossal nerve, and, perhaps, part of glosso-pharyngeal. One-half of the tongue may be removed in the same way, having first split it in the middle line with a bistoury.

The patient must be fed for a time by nutrient enemata, and the mouth washed out very frequently by some warm antiseptic solution; later he may be fed through a tube. In operations on the tongue the only serious immediate danger is hæmorrhage from the divided linguals. The vessel may be compressed from the mouth in the way recommended by Mr C. Heath—pass the forefinger over the dorsum of the tongue till it touches the epiglottis; it is then turned towards the side on which the artery is to be compressed and hooked forcibly up against the jaw. The lingual artery may also be ligatured at the beginning of the operation; the last time I saw this operation performed, Mr Chiene first ligatured the lingual of the side to be removed, making use of the incision at the same time to remove a suspicious gland.

2. **By Incisions below the Jaw.**—Regnoli's incisions were the following:—An incision of semi-lunar shape made along the line of the lower jaw, if possible confined within the space between the two facial arteries; another, a perpendicular incision carried from the centre of the semi-lunar one, under the chin down as far as the hyoid bone, and then the flaps dissected back. Care must be taken not to injure the facial arteries.

Then (*a*) the integuments are cut through, and after this the structures forming the floor of the mouth—viz., (*b*) Anterior bellies of the digastric muscles; (*c*) the mylo-hyoids, transversely at their anterior part; (*d*) insertions of genio-hyoids and of the genio-hyo-glossi; (*e*) mucous membrane of the floor of the mouth. A piece of strong whip cord is then passed through the tip of the tongue, or it is seized with a strong hook-forceps, and drawn through the opening between the lower jaw and the hyoid bone, and removed by the knife or écraseur by dividing its attachments (1) to the epiglottis, viz., the three epiglottidean folds of mucous membrane (a central and two lateral); and (2), to the hyoid bone, viz., the hyo-glossus and genio-hyo-glossus muscles, and the hyo-glossal membrane. The lingual ends of the palato and stylo-glossus will also be divided. The lingual arteries may now be secured, or they may be exposed and tied before removing the tongue; they will be found to pass forwards to the outer side of the genio-hyo-glossi muscles between them and the hyo-glossi. The wound is then stitched up and drained from the lower end of the vertical cut. The great objection to this operation is, that all the muscles that elevate the hyoid bone and larynx are divided, and it consequently interferes with the movements of deglutition and respiration to a certain extent.

Kocher's Method (Fig. 46).—By this method not only the tongue, but the infra-maxillary glands also are removed. He performs a preliminary tracheotomy, and introduces a Trendelenburg's canula, and the facial and lingual arteries are ligatured at an early stage of the operation. The incision he uses is the following:—It begins a little below the lobule of the ear, and is carried

down along the anterior edge of the sterno-mastoid to the level of the great cornu of the hyoid bone. From this point the incision is carried forwards nearly to the

Fig. 46.

KOCHER'S EXCISION OF THE TONGUE.

body of the hyoid, and then upwards along the line of the anterior belly of the digastric to the jaw. The flap is then turned up over the face, and by a careful dissection the submaxillary lymphatic glands and tongue

are removed. The **advantages** claimed for this method are that the dangers from hæmorrhage, septic absorption, and pneumonia are done away with.

3. **By Section of the Lower Lip and Jaw.**—This operation was first performed in this country by SYME. By it the disadvantages of REGNOLI's method are done away with, but there is an additional risk incurred from the section of the lower jaw, and that is the great disadvantage of this operation, as its severity, it is said, is materially increased by division of that bone. A piece of strong whip cord is passed through the tip of the tongue, so as to enable it to be drawn forwards when necessary, and the two central incisor teeth are extracted. Then an incision is made through the central line of the lower lip, across the chin, and down as far as the hyoid bone, and the lower jaw sawn through at the symphysis. It is recommended to make the section of the bone >-shaped, so that the two halves may lock after the operation; or two holes may be drilled in the bone before the section is made by which the two parts may be sutured afterwards. The mucous membrane and genio-hyoglossi muscles are then divided close to the jaw, and the two halves of the bone separated, and the hyoglossi muscles cut through. The tongue is next drawn forwards, and the lingual arteries divided and secured, when it is then removed from the hyoid bone by a stroke of the knife, or gradually removed by the wire écraseur. In this, as in other methods, either both the lingual arteries may be tied before beginning the operation, or else a preliminary laryngotomy may be performed. Not only does this latter plan obviate the dangers arising from the passage of blood down the respiratory passages,

but is believed also to be a safeguard against septic pneumonia, as the patient breathes through the tube and does not therefore inhale septic organisms from the wound in the mouth or jaw, or from the stump of the tongue; the method of continuous irrigation with some warm antiseptic solution, however, should greatly lessen the risk of inhaling septic organisms.

Wry Neck — Torticollis or Caput Obstipum. — *Causes*:—(1) May be congenital, or it may follow measles or scarlatina; (2) long-continued irritation, as from inflamed cervical glands; (3) disease of the cervical vertebræ and their ligaments; (4) traction from the cicatrix of a burn; (5) spasmodic contraction of the sterno-mastoid and trapezius of the same side, from irritation of the spinal accessory, or it may even be due to contraction of the platysma; (6) paralysis of the opposite sterno-mastoid. In this condition there is a three-fold displacement of the head—(1) It is drawn downwards towards the sternum; (2) it is rotated from the affected side, so that the chin points over the opposite shoulder; (3) it is inclined laterally to the affected side. As a cure for some forms of wry neck, it has been proposed to stretch the spinal accessory nerve; but this operation is hardly ever followed by any permanent benefit, and if it is to be interfered with at all, it is better to cut it right through, or even to remove an inch or so out of the trunk of the nerve. Division of the sterno-mastoid is also practiced for the relief of this deformity.

To Stretch the Spinal Accessory Nerve.—This nerve leaves the cranium, in the same sheath of dura mater as the vagus, by the jugular foramen, and after having passed through, is found lying, with the other divisions

of the eighth pair, between the internal jugular vein and the internal carotid artery. It then passes downwards and backwards across the internal jugular vein, and appears below the posterior belly of the digastric, and close to, but below, the transverse process of the atlas, and enters the deep surface of the sterno-mastoid. The great land-mark for this operation is the prominent transverse process of the first cervical vertebra. In this region it may be exposed, and stretched or cut, by an incision along the upper part of the anterior border of the sterno-mastoid, commencing an inch below the mastoid process, and carried downwards for two or three inches. By dividing the superficial structures, and defining the anterior edge of the sterno-mastoid, and then defining the transverse process of the first cervical vertebra, the nerve will be found emerging from below the posterior belly of the digastric, curving round the process above indicated, from before backwards and downwards, and entering the deep surface of the former muscle. The incision must not be carried too far up, lest the external jugular vein (which lies midway between the angle of the jaw and the mastoid process), or the parotid gland be injured. The nerve is also crossed by the occipital artery.

Division of the Sterno-Mastoid.—The part which most frequently requires division is the sternal head, but both heads may be divided. In doing so it is well to bear in mind the proximity of important structures, *e.g.*, the internal jugular vein, and several veins passing to join it, lie behind the muscle, and if care be not taken the operation may be followed by a fatal result: further, the external jugular vein is often close to its outer border, and the anterior jugular at its inner.

The incision should be made from behind, forwards close to the sternum, and along the clavicle, and if this be done, there is little risk of doing any damage; the tension of the muscle tends to make it project forwards, and away from the carotid sheath. The following method is that recommended by ERICHSEN:—For the *sternal* head make a puncture on the inner side of the tendon with a sharp scalpel, and then push a narrow director behind the muscle, and after that pass an ordinary tenotome between the director and the tendon flatwise, turn it and then cut forwards. In dividing the *clavicular* insertion make a puncture with a scalpel upon, and down to the clavicle in the space between the two heads of the muscle, and then push a blunt-pointed, narrow-bladed tenotome between that bone and the insertion of the muscle, and cut forwards, or a director may be used as in the last case. In children the muscle may also be divided about its centre by passing a tenotome behind the muscle, from without inwards, putting it on the stretch and then cutting forwards.

The Deep Fascia of the Neck.—This is attached behind to the spinous processes of the cervical vertebræ. It splits to enclose the trapezius muscle, and then the two layers join to form the roof of the posterior triangle of the neck; it again splits to enclose the sterno-mastoid and the depressor muscles of the hyoid bone, and then unites across the middle line with the fascia of the opposite side. This layer is attached *above* to the base of the lower jaw, the zygoma, mastoid process, the superior curved line and the protuberance of the occipital bone; *below*, to the upper and posterior part of the manubrium sterni. If pus form beneath

this layer, it will in all probability find its way into the anterior mediastinum or else bag over the sternum.

From the deep surface of this layer, as it ensheaths the sterno-mastoid, a strong process passes inwards across the neck, and forms the carotid sheath, and then passes in front of the prevertebral muscles, but behind the pharynx and œsophagus, to unite with the layer of the opposite side. This part is attached *above* to various points at the base of the skull, and specially to the angle of the lower jaw and the styloid process, and the part intervening between these two points is known as the *stylo-maxillary ligament*, which separates the parotid from the sub-maxillary gland. As this layer passes down, it divides into two parts. One is placed beneath the depressors of the hyoid bone, invests the thyroid body and at the sides is attached to the first rib and binds down the central tendon of the omo-hyoid muscle to that bone, while the central part passes down in front of the trachea and large vessels and becomes continuous with the fibrous pericardium. The other layer passes into the thorax in front of the prevertebral muscles but behind the œsophagus. If pus form in *front* of the former it will most likely find its way into the axilla at the side, or anterior mediastinum in front; if behind it, it will gravitate towards the apex of the pleura and lung at the sides, or middle mediastinum in front; if it form beneath the latter division, it will tend to pass into the posterior mediastinum.

THE ANTRUM.

The Antrum of Highmore, or the **maxillary sinus,** is a large triangular-shaped cavity, hollowed out in

the body of the superior maxilla. Its *apex* is directed outwards, and its *base* is formed by the outer wall of the nose. Its *roof* is very thin, and is formed by the orbital plate of the maxilla, its *floor* is formed by the alveolar process, its anterior wall by the facial, and its posterior by the zygomatic surface. Its aperture is near the upper level of the cavity, and communicates with the middle meatus of the nose, the position of the opening being about the centre of the outer wall of the nasal cavity; the opening here is sufficiently large to admit the end of a small probe. Projections into the floor are made by the fangs of the first and second molar teeth usually, but others may also project as well. A growth in the cavity may, therefore, readily encroach upon the orbit above, displacing the eyeball and giving rise to double vision; the nose on the inner side, closing up that cavity; in front, causing a projection on the cheek; behind, into the zygomatic fossa, and downwards, into the floor of the mouth.

Diseases of this Cavity.—1. **Tumours**—(*a*) *malignant* often begin in the antrum, such as sarcomata and epithelioma; (*b*) *simple*, such as enchondroma, fibroma, osteoma, &c. 2. **Suppuration and Abscess**—This may arise from (*a*) inflammation spreading from the nose and blocking up the opening of the antrum leading to tension and abscess; (*b*) from disease of the teeth; (*c*) in weak debilitated strumous, children after fevers, &c., and in such cases there is often disease of the bone as well; (*d*) it may arise from injury. If the opening is not blocked up, then the pus may overflow into the nostril, especially when the patient lays the sound side of the head flat on a pillow; but if the opening be blocked up it will most probably point at the upper

part under the orbit, or through the thin canine fossa lower down. 3. **Dropsy**—The cavity either becomes slowly filled with a glairy fluid like that found in ranula, or it may be thin and serous. It is not due to the blocking up of the orifice into the nose, but from a cystic degeneration of the mucous membrane, resembling somewhat the ordinary mucous polypus of the nose. When it was believed to be an accumulation of fluid resulting from a closed orifice, then the operation of 'catheterization' of the antrum was advised; this, as might be expected, from the erroneous pathology, was not followed by any benefit to the patient. 4. **'Dentigerous' cysts**—These arise in connection with a misplaced or inverted permanent tooth. They may be recognised by the absence of a tooth from its proper place in the jaw.

FRACTURES OF THE BASE OF THE SKULL.

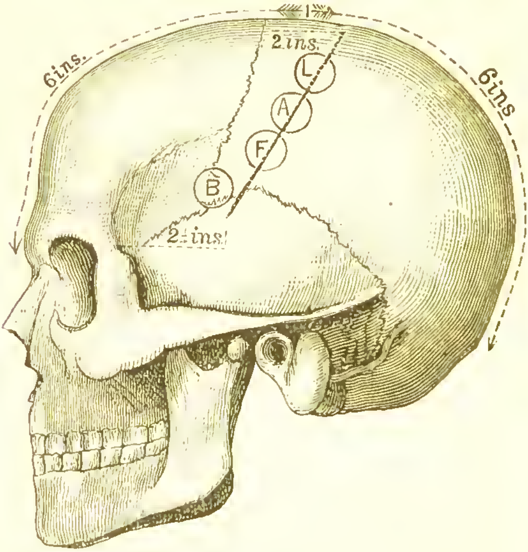
These are usually caused by (1) a blow or fall on the top of the head, and a fracture extending from the part struck through the petrous portion of the temporal bone. (2) Sometimes by a fall on the feet or buttocks by the impact of the spine against the condyles of the occipital bone. (3) By direct violence, as a knife or umbrella driven into the orbit or nose, or a pistol shot in the mouth. (4) Genuine *contre coup*, where the skull is struck, say on the vertex or sides, fracturing the base, yet there is no fissure radiating from the point struck. In the **anterior fossa** there is extravasation of blood into the orbit, and *under* the conjunctiva and skin of the lid, or possibly bleeding from the nose, *sometimes* followed by the escape of cerebro-spinal fluid; the first and second pairs of cranial nerves may also be

damaged. When the hæmorrhage is beneath the conjunctiva it is of a fan-shaped form and the blood retains its scarlet colour as the oxygen readily reaches it through that membrane; in these respects it differs from a black eye, for in this condition there is bruising of the superficial textures, and the hæmorrhage is chiefly *in* the skin. In the **middle fossa**, the most characteristic sign is bleeding from the ear, followed by the discharge of a watery fluid, as the fracture is usually through the petrous portion of the temporal bone, and the tympanic membrane is ruptured, as well as the sheath of arachnoid surrounding the facial nerve in the internal auditory meatus. The fluid has the **characters of cerebro-spinal fluid**—very watery and limpid, containing much chloride of sodium, a trace of albumen, the faintest trace of sugar, and is not coagulated by heat or nitric acid. Other possible sources of this fluid have been suggested—a secretion from the mucous membrane of the tympanic cavity, serum from a blood clot, the liquor Cotunnii *(perilymph)*. In fracture of this fossa the facial nerve is often implicated; other nerves in this region may also suffer. In fracture of the **posterior fossa** the signs are very obscure. There may be deep seated extravasation of blood producing a yellowish discolouration of the skin some days after the accident. There will also probably be some tenderness about the mastoid process.

Motor Areas.—The motor areas are situated immediately in front of and behind the **fissure of Rolando**. This **fissure** (Fig. 17) runs up not quite parallel with the coronal suture, being from one and a half to two inches behind it at the vertex, but only a little more than an inch at its lower end. According to THANE,

the upper end of the fissure of Rolando is placed half an inch behind a point midway between the root of the nose and the external occipital protuberance; its lower end, for all practical purposes, is situated about two and a quarter inches behind the external angular process of

Fig. 47.



FISSURE OF ROLANDO AND MOTOR AREAS.

B. Broca's convolutions. F. Face centre. A. Arm centre. L. Leg centre.

the frontal bone. On the *left* side, at the lower and anterior part is BROCA's convolution (centre for speech); close to this are found the centres for the tongue and lips. Higher up is the face centre, then the centres for the upper limb, and last and highest of all are found the centres for the lower limb. So therefore, not only are the centres for the two sides of the body reversed, those for the left half of the body being on the right

side of the brain, but they are turned upside down as well. In cases demanding the trephine it is, of course, to be done on the side opposite to that on which the paralysis exists.

The most important malformations of the brain visible externally are—1. **Meningocele,** where the protrusion consists of a part of the membranes filled with cerebro-spinal fluid. It is as a rule of small size, pedunculated, fluctuating, and translucent, and may be entirely reduced. 2. **Encephalocele,** where the protrusion consists of brain as well as membranes. It does not fluctuate, and is opaque, but pulsates along with the rest of the brain, and may be partly reducible. 3. **Hydrencephalocele,** where the protruded brain is distended by an accumulation of fluid within the ventricles; it is very often large, fluctuates, and may sometimes pulsate. These malformations are believed to be due to intra uterine hydrocephalus, and not merely to want of development of the bones of the skull. The tumours are soft rounded, bluish in colour, and covered by thin skin, increase in size when the child cries, and have been mistaken for nævi. Several interesting cases are recorded by Mr HUTCHINSON in his '*Illustrations of Clinical Surgery*.' They are usually found in the middle line, and most frequently at the back of the head through an opening in the occipital bone at the junction of the four centres from which the supra-occipital portion is developed. It is also seen at the root of the nose between the two halves of the frontal bone, at the anterior and posterior fontanelles, and occasionally at the sides of the skull. When at the anterior part of the skull they always communicate with the lateral ventricles: those at the sides with the

third or lateral, and those in the occipital region with the fourth. It has also been seen in the nose and mistaken for polypus. The **diagnosis** depends (1) they are congenital and at the seat of some membranous part of the fœtal skull; (2) they fluctuate, as they are fluid in nature; (3) they increase in volume when the child cries; (4) they are partly or wholly reducible; (5) they partake of the movements of the brain, pulsate, &c.

CRANIAL NERVES.

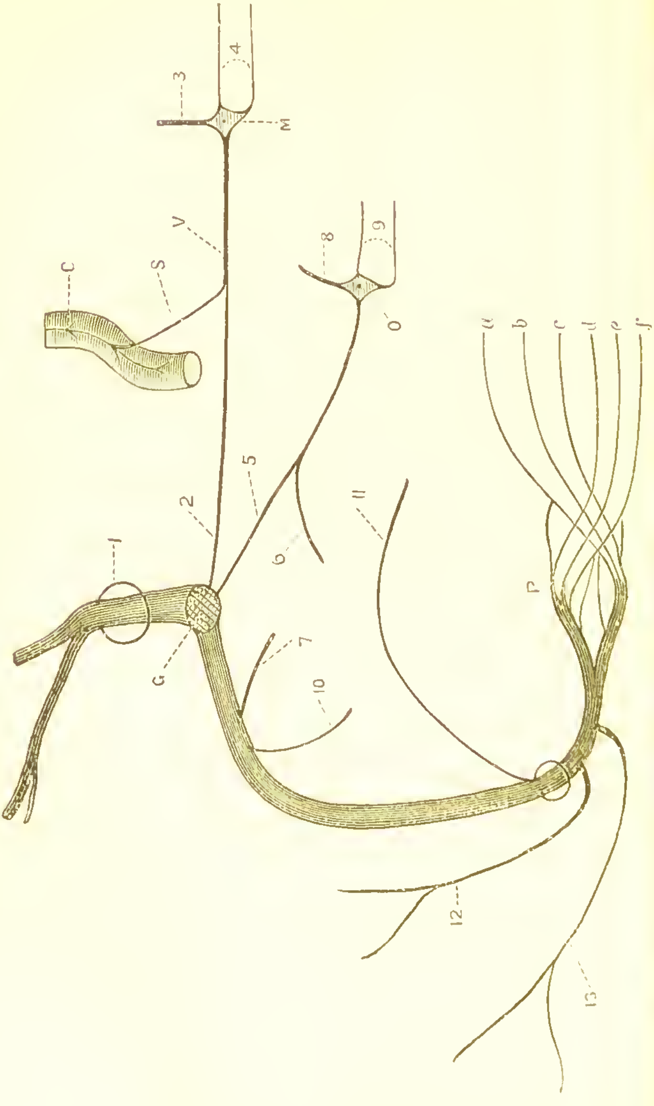
Facial Nerve *(portio dura of seventh)*.—This is the motor nerve of the face. Its deep origin is from the upper part of the floor of the fourth ventricle, and from the lenticular nucleus of the *opposite* side; the fibres of the *portio intermedia* can be traced into the glosso-pharyngeal nucleus. It enters the internal auditory meatus to the inner side of and above the auditory *(portio mollis)*. At the bottom of the meatus it enters the aqueduct of Fallopius, traverses that canal and makes its exit at the stylo-mastoid foramen (Fig. 48). In the bone it first passes *outwards* then *backwards*, forming the knee-shaped bend, where there is a gangliform enlargement (the *geniculate ganglion*), and after this it passes straight down to the stylo-mastoid foramen. It then divides in the parotid gland into *temporo-facial* and *cervico-facial* divisions; these, by a series of divisions and anastomoses, form the *pes anserinus*, from which branches pass to supply all the muscles of expression—except the buccinator.

Branches.—In the *meatus* it communicates with the auditory nerve. In the *aqueduct*—(*a*) The great superficial petrosal nerve from the ganglion, passing out at the hiatus Fallopii, grooving the anterior surface

of the petrous part of the temporal bone, then running underneath the fifth nerve and Gasserian ganglion, it is joined by a twig from the sympathetic (carotid plexus), and after this is known as the Vidian nerve, which partly passes through the foramen lacerum medius into the Vidian canal, and enters Meckel's ganglion, of which it forms the motor root, and is distributed to the azygos uvulæ and levator palati muscles. (*b*) Small superficial petrosal, also from the ganglion, and takes a course similar to the last, but passes out at the foramen ovale and enters the *otic ganglion*, to which it conducts the secretory fibres for the parotid gland. (*c*) Next in order is the external superficial petrosal, which joins the facial from the sympathetic plexus on the middle meningeal artery. (*d*) Next comes the tympanic branch to supply the stapedius muscle and the laxator tympani; and lastly (*e*) the chorda tympani, which is given off just before the nerve makes its exit from the stylo-mastoid foramen. This nerve has already been seen in the middle ear, after which it passes through the canal of Huguier and joins the lingual branch of the fifth at an acute angle between the two pterygoid muscles, and passes with that nerve to the tongue, forming the nerve of taste to the anterior two thirds; it is also secretory to the sublingual and the submaxillary glands.

After the nerve has left the bone it gives off the (*a*) *posterior auricular* branch which supplies the skin and posterior belly of the occipito-frontalis muscle; (*b*) a branch supplying the stylo-hyoid and posterior belly of the digastric: (*c*) branches from the *pes* supplying the muscles of expression from the brow to the chin—except the buccinator. These muscles are situated around the cavities of the orbit, nose and mouth.

Fig. 48.



1. Beginning of the aquæductus Fallopii. G. Gasserian ganglion. 2. Great superficial petrosal. C. Internal carotid artery, with carotid plexus of sympathetic. S. Sympathetic twig to join the great superficial petrosal. V. Vidian nerve. M. Meckel's ganglion. 3. Its sensory root, from the second division of the fifth. 4. Its branches to the azygos uvulæ and levator palati muscles. 5. Small superficial petrosal. 6. Twig from Jacobson's nerve, joining the small superficial petrosal, probably the secretory fibres for the parotid gland. O. Otic ganglion. 8. Its motor root, from the third division of the fifth. 9. Its branches to the tensor tympani, and the tensor palati muscles. 7. The external superficial petrosal. 10. Nerve to the stapedius. 11. Chorda tympani. 12. Posterior auricular. 13. Branch to supply the stylo-hyoid and the posterior belly of the digastric. P. Pes anserinus. *a*. Temporal branch, to occipito-frontalis. *b*. Malar branch, to muscles round eye. *c*. Infra-orbital branch, to muscles about the nose. *d*. Buccal branch, to orbicularis oris and buccinator. *e*. Supra-maxillary, to lower lip and chin. *f*. Infra-maxillary, to platysma, &c.

PARALYSIS.—This nerve may be paralysed—

1. **At or after its Exit from the Stylo-Mastoid Foramen.**—This is, properly speaking, 'Bell's paralysis.' The **signs**—(*a*) The wrinkles disappear from the brow, giving it a smoother appearance than the other side. (*b*) The eye-lids can't be closed. (*c*) The lower lid falls down, and the punctum is drawn away from the globe, hence the tears run over the cheek. (*d*) The nostrils cannot be dilated. (*e*) The mouth and face are drawn towards the sound side. (*f*) The buccinator is paralysed, and the food passes between the teeth and the cheek; the cheek is flabby and falls in and may be caught by the teeth. (*g*) Can't whistle or laugh properly, the angle of the mouth is depressed and drawn to the sound side. (*h*) The posterior belly of the digastric and stylo-hyoid muscles are paralysed.

2. **It may be Paralysed in the Petrous Bone,** as in disease of the middle ear, fracture of the base, &c. In this case the signs will vary with the height at which the nerve is affected, they will be given here from below upwards. In addition to the previous symptoms we will therefore have—(*a*) Loss of taste in the anterior two-thirds of the tongue, because the chorda tympani is paralysed. (*b*) The sense of hearing will be affected, as the stapedius muscle is paralysed—increased sensitiveness to loud sounds. (*c*) The mouth will be dry because the salivary glands are not secreting (the lower two by the chorda, the parotid through the small superficial petrosal). (*d*) The palate falls down on the paralysed side, because the levator and azygos uvulæ muscles are paralysed (through the great superficial petrosal.

3. The paralysis may be **central**, that is in the brain.

In this case, curiously enough, the *upper* part of the face usually escapes—the brow and the muscles centring round the orifice of the orbit. This is probably because of the fasciculus of fibres that arise from the opposite side.

Meckel's, or the Spheno-Palatine Ganglion.—This structure is deeply placed in the spheno-maxillary fossa, close to the spheno-palatine foramen, on a level with the root of the pterygoid processes, and immediately below the superior maxillary nerve.

Roots.—(*a*) *Sensory* from the second division of the fifth as it lies immediately above it, crossing the spheno-maxillary fossa. (*b*) *Sympathetic* from the carotid plexus through the Vidian. (*c*) *Motor* from the facial *(great superficial petrosal)*, through the Vidian also. The ganglion may be most readily exposed by removing the upper jaw, and it is probably always exposed in that operation. It will be found in the spheno-maxillary fossa, immediately in front of the Vidian canal, and connected with the Vidian nerve. Its **branches** are motor to the levator palati, and azygos uvulæ muscles, and also to the muscle of Müller; for the rest, it is sensory to the nose, pharynx, and palate.

Second Division of the Fifth *(superior maxillary nerve).*—It arises from the Gasserian ganglion, leaves the skull by passing through the foramen rotundum into the spheno-maxillary fossa, crosses that fossa and enters the orbit through a fissure of the same name, and then enters a canal on the floor of the orbit, appearing on the face at the infra-orbital foramen where it divides, beneath the levator labii superioris, into palpebral, nasal, and labial branches. It is purely a sensory nerve. Its **branches** in the *fossa* are—(*a*)

orbital or temporo-malar, (*b*) spheno-palatine to Meckel's ganglion, (*c*) posterior dental to the teeth of the upper jaw. In the *infra-orbital* canal it gives off the anterior dental branches.

The Third Division of the Fifth *(inferior maxillary).*—This is the largest division, and, like the last, it arises from the Gasserian ganglion, leaves the skull through the foramen ovale, and is then joined by the motor root of the fifth, and thereafter divides into a small or *anterior division,* chiefly motor in function, and a large or *posterior division,* chiefly sensory. From the *anterior* division proceed (*a*) the masseteric nerve to the masseter muscle; (*b*) two deep temporals to the temporal muscle; (*c*) branches to the two pterygoids, and lastly, the long buccal nerve. This division, it will be noted, supplies the muscles of mastication. From the *posterior* division come (*a*) the auriculo-temporal; (*b*) the inferior dental; (*c*) gustatory or lingual nerve. From the lingual comes the mylo-hyoid nerve which supplies the mylo-hyoid muscle and the anterior belly of the digastric.

The Otic Ganglion *(Arnold's).*—This ganglion lies immediately below the foramen ovale, on the inner surface of the inferior maxillary nerve, and round the origin of the nerve to the internal pterygoid muscle, and in front of the middle meningeal artery. Its **roots** are—(*a*) *Motor* from the internal pterygoid nerve (third division of fifth), which is the guide to the ganglion, and through which it supplies the tensor palati and the tensor tympani muscles; (*b*) *Sensory* from the auriculo-temporal; (*c*) *Sympathetic* from the plexus on the middle meningeal artery; (*d*) it also communicates with the facial and glosso-pharyngeal through the small

superficial petrosal. Its secretory fibres probably come from the tympanic branch of the glosso-pharyngeal *(Jacobson's nerve)*, *viâ* the small superficial petrosal and auriculo-temporal nerves, and the otic ganglion.

To **expose this ganglion** necessitates the dissection of the **Pterygo-Maxillary Region.**—1. Clear out the parotid gland and the structures in it (see p. 538). 2. Remove structures on the masseter—(*a*) Part of the parotid gland and socia: (*b*) Stenson's duct; (*c*) transverse facial artery and veins; (*d*) facial vein; (*e*) branches of facial nerve and great auricular; (*f*) risorius muscle and some lymphatic glands. 3. Remove the two layers of temporal fascia above the zygoma, and saw through that bone in front and behind, and throw it down with the masseter muscle. 4. Snip off the coronoid process and throw it up along with the temporal muscle, and then saw through the ascending ramus, first at the neck of the condyle, and again at the level of the molar teeth. This now exposes the first and second parts of the internal maxillary artery, the two pterygoid muscles, and the chief branches of the third division of the fifth. 5. Now disarticulate the condyle of the jaw and throw it forwards with the external pterygoid muscle when the foramen ovale, the trunk of the third division of the fifth, and chorda tympani nerves are all exposed. Lastly, secure the nerve to the internal pterygoid muscle, and trace it up to the ganglion.

Hypoglossal Nerve *(ninth, motor linguæ)*.—It arises from the fourth ventricle, near the point of the calamus scriptorius. It leaves the skull, often in two bundles, through the anterior condyloid foramen, and then lies at first behind the internal carotid artery and internal jugular vein, next it passes between the artery and the

vein, hooks round the occipital, and crosses the external carotid artery, and passes beneath the digastric and mylo-hyoid muscles to the tongue. Its **Branches** are (*a*) *descendens noni*, which forms a loop (ansa hypoglossi) with the communicans noni, and supplies both bellies of the omo-hyoid, the sterno-hyoid, and the sterno-thyroid muscles. (*b*) A *special branch* to the thyro-hyoid. (*c*) Branches to the genio-hyoid, genio-hyo-glossus, the hyo-glossus, and the stylo-glossus. Lastly, it supplies the intrinsic muscles of the tongue.

In **paralysis** of this nerve the tongue is pushed to the paralysed side. In long standing cases the paralysed half of the tongue atrophies.

CHAPTER XXX.

THE UPPER EXTREMITY.

The more important points about the **surface anatomy** have already been pointed out when speaking about fractures and dislocations, and I would only point out the groove on each side of the biceps in the upper arm; the outer one corresponds pretty closely to the course of the cephalic vein; the inner to the brachial artery and the basilic vein.

THE AXILLA.

In describing this space note—(*a*) *Position*—It is a space between the upper part of the arm and the upper part of the side of the chest. (*b*) *Shape*—In shape it resembles a four-sided pyramid but the sides are not equal—the inner side is much larger than the outer, and the posterior wall extends further down than the anterior. (*c*) *Boundaries*—The *base* is formed by the integuments and the strong axillary fascia: the *apex* is directed upwards towards the root of the neck, and corresponds to an interval between the first rib, clavicle, and upper border of the scapula, and is triangular in shape. The *anterior* wall is formed by the pectoralis major and minor: *behind* are the subscapularis, latissimus dorsi and teres major: to the *inner* side, the upper five or six ribs with their intercostal muscles, and

upper part of serratus magnus: the *outer* wall is formed by the coraco-brachialis, short head of biceps, head and neck of humerus. (*d*) The *contents*:—

(1) The axillary artery and its branches.

(2) The axillary vein and its tributaries.

(3) The brachial plexus of nerves and its infra-clavicular branches.

(4) Lymphatic glands, fat and areolar tissue.

(5) Lateral cutaneous branches of the upper three or four intercostal nerves.

(6) Nerve of Bell.

1. **Glands of the Axilla.**—The lymphatic glands of the axilla are arranged in three sets—(1) one group lies along the subscapular artery in the posterior fold of the axilla; (2) another group accompanies the long thoracic artery in the anterior fold of the axilla; (3) while the third is placed along the axillary artery. The posterior group receives lymphatics from the side of the chest and back, the anterior group from the front of the chest and mamma, while those placed along the axillary vessels receive the lymphatics from the forearm and hand, and upper limb generally. A knowledge of these facts is of practical value, because disease in the parts from which the lymphatic vessels come will point to the group of glands likely to be affected; thus, in disease of the mamma (*e.g.*, cancer) the anterior group will be enlarged, and in a poisoned wound of the hand, the group along the axillary artery will be affected, and so on.

2. **Abscess in the Axilla.**—If pus form in the axilla, it will be unable to make its way to the surface through the base of the space on account of the strong axillary fascia which is found in this region, but will rather

burrow up towards its apex, and point in the neck, or may even open into the pleura. The necessity, therefore, of making an early and free incision for its evacuation is evident.

3. **The Relation of the Contents of the Axilla to its Walls.**—In the *outer* wall are the large axillary vessels and nerves; in the *anterior* wall there is a large vessel—the long thoracic artery; in the *posterior* wall there is also a large vessel—the subscapular artery; in the *inner* wall we find the nerve of Bell and the superior thoracic artery, but the artery is small and placed high up. In making incisions, therefore, into the axilla, as for the evacuation of pus, the operator must cut *towards the inner wall* in order to avoid the important structures in relation to the other walls of the space, or else use Hilton's method.

4. **Pressure on the Brachial Plexus.**—Pressure on this plexus, as from a tumour in the axilla, or in subglenoid dislocation of the humerus, will cause a severe numb pain to be felt in the hand and arm.

THE BRACHIAL PLEXUS.

The Brachial Plexus is formed by the anterior primary divisions of the fifth, sixth, seventh, and eighth cervical nerves, and half of the first dorsal; it also receives a branch from the fourth cervical nerve. They lie in grooves on the upper surface of the transverse processes of the cervical vertebræ, and appear in the neck between the scalenus anticus and the scalenus medius muscles; here they lie in the posterior triangle of the neck (clavicular part), and they then pass between the clavicle and the first rib into the axilla as far as the coracoid process, or the insertion of the

pectoralis minor, where it forms its three cords. The three cords are formed thus:—The fifth and sixth unite to form a single trunk; the seventh passes down alone; the eighth cervical and the first dorsal unite to form another trunk. The three cords formed in this manner then divide each into an anterior and a posterior branch; the anterior branches of the upper and middle join to form the *outer* cord; the anterior branch of the lower forms the *inner* cord, while the posterior branches all unite to form the *posterior* cord. Its **branches** are divided into (*a*) supra-clavicular, (*b*) infra-clavicular.

The **supra-clavicular** branches are:—(1) Communicating to the phrenic (from the fifth); it joins the phrenic on the scalenus anticus. (2) Nerve to rhomboids (from fifth). (3) Nerve of Bell, by two heads (from the fifth and sixth). (4) Supra-scapular, from the posterior part of the cord formed by the fifth and sixth. (5) Nerve to the subclavius, from the anterior part of the cord formed by the fifth and sixth, and which passes down, in front of the third part of the subclavian, to the muscle.

The **infra-clavicular** branches are:—

From the *outer* cord—

(1) External anterior thoracic.
(2) Outer head of median.
(3) Musculo-cutaneous.

From the *inner* cord—

(1) Internal anterior thoracic.
(2) Inner head of median.
(3) Ulnar.
(4) Internal cutaneous.
(5) Lesser internal cutaneous (nerve of Wrisberg).

From the *posterior* cord—

(1) Musculo-spiral.

(2) Circumflex.

(3) The three subscapular nerves.

The Axillary Fascia.—This is a dense sheet of fascia forming the floor or base of the axilla. It becomes continuous in *front* with the fascia over the serratus magnus; at the *outer* side it is continuous with the deep fascia of the arm, and receives fibres from the tendons of the latissimus dorsi and teres major; it also becomes continuous with the deep fascia ensheathing the muscles forming the anterior and posterior walls of the axilla. In this way a strong fascial chamber is formed, only open at the upper part at the root of the neck. In operations in the axilla care must be taken to prevent the entrance of air into the large axillary vein. This is apt to take place, first, because of its position so close to the chest, and therefore subject to the aspirating power of that cavity during inspiration; and, secondly, because it is surrounded and held open by the dense fascia of this region.

THE BEND OF THE ELBOW.

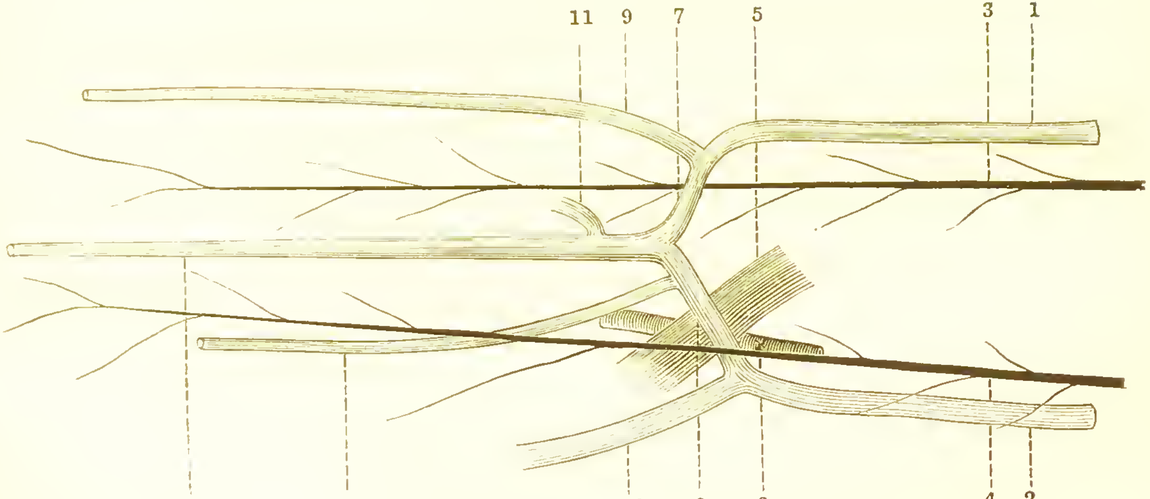
The Triangle in Front of the Elbow Joint *(anti-cubital fossa)*.—This space is bounded on the *outer* side, by the supinator longus; on the *inner* side, by the pronator radii teres; the *base* is an imaginary line drawn across the arm at the level of the condyles; the *apex* is the meeting of the supinator longus and the pronator radii teres. The *roof* is formed by the skin, superficial and deep fascia, cutaneous nerves, median cephalic and median basilic veins; the *floor* is

formed by the supinator brevis and the tendon of insertion of the brachialis anticus. The **contents**, from within outwards, are:—(1) The median nerve; (2) the brachial artery and venæ comites; the artery in this space divides into its radial and ulnar branches. (3) Tendon of the biceps. (4) By pulling the supinator longus outwards a little, the musculo-spiral nerve will be seen dividing into radial and posterior interosseous, and also the anastomoses between the radial recurrent and superior profunda. And by displacing the pronator radii teres a little inwards the anastomoses between the anterior ulnar recurrent, inferior profunda, and anastomotica.

Veins at the Bend of the Elbow (Fig. 49).—Passing up the centre of the forearm is the median vein, which, when it reaches the hollow in front of the elbow joint, divides into the median basilic and the median cephalic veins. The median cephalic is joined by the radial vein, then passes up the arm as the cephalic vein, and empties itself into the axillary vein. The median basilic is joined by the anterior and posterior ulnar veins, then passes upwards as the basilic vein, and about the middle of the arm pierces the deep fascia, and is joined by the venæ comites of the brachial artery, and is then known as the axillary vein. At the bend of the elbow the median basilic vein overlies the brachial artery, but is separated from it by the semi-lunar or bicipital fascia, and the internal cutaneous nerve passes over or under it, while the external cutaneous passes under the median cephalic.

Venesection at the Bend of the Elbow.—Either of these (median cephalic or median basilic) may be opened. The median basilic is the larger, and more easily com-

Fig. 49.



VEINS AT THE BEND OF THE ELBOW, RIGHT SIDE.

1. Cephalic vein. 2. Basilic vein. 3. External cutaneous nerve. 4. Internal cutaneous nerve. 5. Bicipital fascia. 6. Brachial artery. 7. Median cephalic vein. 8. Median basilic vein. 9. Radial vein. 10. Posterior ulnar vein. 11. Profunda branch. 12. Anterior ulnar vein. 13. Median vein.

pressed and fixed, because it has the firm bicipital fascia behind it; its great disadvantage is that it lies just over the brachial artery, so that if the operation be performed carelessly, or if the patient start during the entering of the lancet, it may pass through the vein and fascia into the artery beyond. The median cephalic is not quite so large, although it is large enough to afford a good stream of blood, but it is separated by a considerable interval from the brachial artery. **Operation.**—Whichever vein be chosen, the steps of the operation are practically the same—(1) A bandage is tied round the arm above the point where the vein is to be opened, to make it 'rise,' but must not be drawn too tightly lest the flow through the brachial artery also be checked. (2) The thumb is then pressed on the vein, just below the point where it is to be opened, in order to steady it. (3) The point of the lancet is then pushed into the vein and made to cut an *oblique* opening—because if longitudinal the flow is too meagre, and if transverse the vein might be completely divided—taking care that the opening in the skin is larger than that in the vein, lest blood escape into the cellular tissue and give rise to 'thrombus.' If the flow be sluggish, the patient should move his fingers while he grasps something firm in his hand, so as to compress the deep veins and cause the blood to flow into the superficial set through the profunda communication. When enough blood has been extracted, place the thumb over the wound, and remove the bandage, or 'fillet,' bend the arm and apply a compress of lint, and fix it by a figure-of-eight bandage and sling the arm.

If the artery be punctured during the operation, this

injury will be manifested by (1) the blood being redder than it should be; (2) that it escapes in jerks, and (3) pressure on the vein below the opening does not stop the bleeding. The results of such an accident are various; it may lead to (1) a *false aneurism*, that is, the blood poured from the artery may be enclosed in a sac, not formed by the coats of the vessels as in true aneurisms, but by the surrounding tissues; (2) it may lead to an *aneurismal varix*, that is, when the wounded artery and vein adhere at the wounded point, and jets of blood are driven into the vein from the artery, dilating it, and causing incompetency of its valves, and leading to a varicose state of the veins in the neighbourhood; it may lead to a *varicose aneurism*, that is, an aneurism the sac of which communicates with both artery and vein, and blood from the artery is projected into the vein *through* the sac of the aneurism. (4) It may also set up septic lymphangitis from the use of a dirty lancet. (5) Sometimes a very painful neuralgic condition results probably from the cutaneous nerve of the corresponding side being involved. (6) Less frequently 'bent arm' results probably from some injury to the cutaneous filaments of the musculo-cutaneous, setting up irritation and causing reflex contraction of the biceps and brachialis anticus (HILTON).

The **Lowest Lymphatic Gland** of the upper extremity is placed a little above the internal condyle, towards the anterior aspect of the arm. It very frequently inflames and suppurates as a result of poisoned wounds of the hand and fingers, as it arrests the poison (*ptomaine*) before it reaches the axillary glands.

Synovial Membranes of the Wrist.—These are *five*

in number. (1) The membrana sacciformis, which lines the lower end of the ulna, the sigmoid cavity of the radius, and the upper surface of the triangular fibro-cartilage. (2) The second lines the wrist joint proper—*i.e.*, the end of the radius and the triangular fibro-cartilage above, and the scaphoid, semi-lunar and cuneiform bones below. (3) The third is the most extensive; it covers the contiguous surface of the two rows of carpal bones, and, passing between the bones of the second row, lines the carpal ends of the four inner metacarpal bones. (4) The fourth lies between the trapezium and metacarpal bone of the thumb. (5) The fifth is between the pisiform and the cuneiform bones. We see, therefore, that one synovial membrane (the third) does for all the carpal bones except the pisiform, and also for all the meta-carpal bones except the first (that of the thumb).

The Sheaths of the Flexor Tendons.—When erysipelatous inflammation attacks the sheaths of the flexor tendons in the fingers (whitlow), it is excessively painful owing to the resistant nature of the structures attacked, and consequent tension, and it is at the same time fraught with danger to the utility of the finger or hand. Pus forms very rapidly, and finds its way up the synovial sheaths of the flexor tendons to the hand and common synovial sheath under the anterior annular ligament; and, if the disease be not checked by timely interference, the sheaths and tendons are rapidly destroyed, the joints of the fingers injured, and the phalanges may even necrose or the finger become gangrenous, and the erysipelatous inflammation extend up the forearm. Suppuration occurring in the sheaths of the tendons of the little finger, or thumb, is far

more likely to involve the common sheath under the anterior annular ligament than when it occurs in any of the other fingers; because the synovial sheaths of the flexor tendons of the thumb and the little finger communicate directly with the common sheath, while those of the three other fingers do not; but, in no case,

Fig. 50.

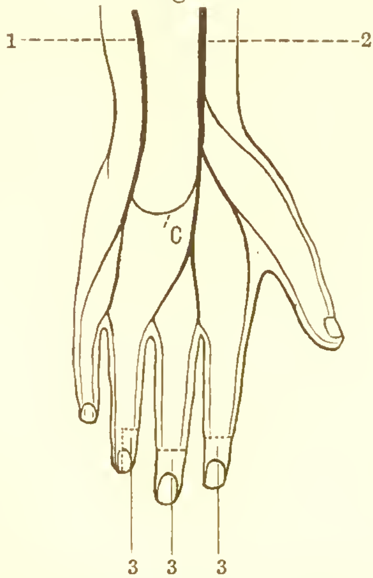
PALMAR CUTANEOUS NERVES.

1. Ulnar nerve. 2. Median nerve.

however, is the distance between the common sheath and the synovial sheaths of the flexor tendons great. To check the spread of the inflammation and relieve the tension, it is advisable either to foment the finger with warm water, or make an early and free longitudinal incision into the finger, and if the pus has formed

within the sheaths, make an incision down to the bone at once. If pus form or accumulate in the common synovial membrane under the anterior annular ligament, the appearance presented is peculiar—there is a swelling in the palm and another in the lower part of the forearm, with a constriction between, caused by the annular ligament. Passing beneath the anterior annular ligament, and enveloped by a common synovial sheath, we

Fig. 51.



DORSAL CUTANEOUS NERVES.

1. Ulnar nerve. 2. Radial nerve. C. Communicating branch. 3. 3. 3. Parts supplied by the median.

find—(1) the tendons of the flexor sublimis; (2) the tendons of the flexor profundus; (3) the tendon of the flexor longus pollicis; (4) the median nerve.

Cutaneous Nerves of the Fingers.—In *front* (Fig. 50), the median nerve supplies the thumb, index and middle fingers, and the radial half of the ring

finger; the ulnar supplying the ulnar side of the ring, and the whole of the little finger. *Behind* (Fig. 51), the radial nerve supplies the fingers supplied by the median in front, *except* the ungual phalanges of the index and middle fingers, and the radial half of the ungual phalanx of the ring finger, which are supplied by the median; the ulnar supplies the remaining one and a half, just as on the anterior aspect.

CHAPTER XXXI.

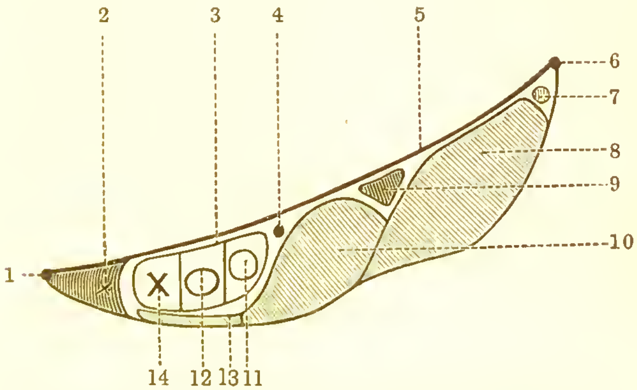
THE LOWER EXTREMITY.

Poupart's Ligament.—This is a strong fibrous band stretching between the anterior superior iliac spine and the spine of the pubes; it is part of the insertion of the external oblique muscle of the abdomen, and separates the thigh from the belly, and the external abdominal ring from the saphenous opening, and is an important diagnostic landmark between ingunial and femoral hernia. It is often known as the *Crural Arch.* Filling up the gap between this ligament and the bone we find the following **structures** (Fig. 52):—(1) External cutaneous nerve; (2) iliacus muscle; (3) the psoas muscle; (4) the anterior crural nerve lying in the groove between these two muscles, and separated from the femoral sheath by a small part of the psoas; at this part of its course the nerve is not round, but may be triangular or quadrilateral in shape. (5) The crural branch of the genito-crural nerve lying on the femoral sheath; (6) the femoral sheath with its component parts, compartments and contents—artery most external, the vein in the middle, and the beginning of the crural canal most internal (see 'Femoral Hernia'); (7) below the sheath, the origin of the pectineus; (8) Gimbernat's ligament—a continuation of Poupart's—along the pectineal line, and part therefore of the insertion of the

external oblique; (9) the accessory obturator nerve, in cases where this nerve exists.

Superficial Glands of the Groin.—These glands are arranged in two rows—one disposed irregularly along Poupart's ligament, the other disposed vertically along the inner side of the thigh, or grouped irregularly

Fig. 52.



STRUCTURES BETWEEN POUPART'S LIGAMENT AND THE BONE.

1. Spine of pubes. 2. Gimbernat's ligament. 3. Femoral sheath. 4. Crural branch of genito-crural nerve. 5. Poupart's ligament. 6. Anterior superior spine. 7. External cutaneous nerve. 8. Iliacus muscle. 9. Anterior crural nerve. 10. Psoas muscle. 11. Femoral artery. 12. Pectineus muscle. 13. Femoral vein. 14. Crural ring.

around the saphenous opening. The first of these receives the lymphatic vessels from the genital organs, abdominal, perineal, and gluteal regions; the other group receives the lymphatic vessels from the lower extremity. These glands frequently become enlarged in diseases implicating the parts from which their lymphatics spring (bubo). Thus, in malignant or syphilitic affections of the genital organs, abscess of the perinæum, &c., the glands along Poupart's ligament

will be implicated, while the vertical set will be enlarged in affections of the lower limb and foot.

SCARPA'S TRIANGLE.

This is a triangular space situated at the upper third of the anterior surface of the thigh; from base to apex it is about a hand's breadth in extent—about four inches. **Boundaries.**—On the *outer* side the inner border of the sartorius; on the inner side the *inner* prominent half of the adductor longus: its *base* is formed by Poupart's ligament, and its *apex* is formed by the crossing of the sartorius over the adductor longus. Its *roof* is formed by the skin, superficial and deep fascia, and the cribriform fascia. The **cribriform fascia** closes up the saphenous 'opening,' and is pierced by a large number of lymphatic vessels (hence its cribriform appearance); it is also pierced by the long saphenous vein. This is the longest vein in the body; it passes through the cribriform fascia, at the lower end of the saphenous opening, just above the inferior cornu. Just before it passes through it is joined, usually as a common trunk, by the veins corresponding to the three superficial branches of the femoral artery. At this point the vein is frequently the subject of the diseased condition known as **Varix**; some believe that this is due to the vein being semi-strangulated by the dense fascia forming the inferior cornu of the saphenous opening, and to relieve the condition, and cure the disease, suggest that the dense fascia should be divided. The *floor* of the triangle is formed by (beginning at the outer side) the iliacus, psoas, pectineus, sometimes part of adductor brevis, and adductor longus muscles. **Contents.**—(1) Femoral sheath; (2) femoral artery, giving off the

cutaneous branches and the profunda; (3) femoral vein with its tributaries, the long saphena and profunda veins; (4) anterior crural nerve and its branches; (5) the external cutaneous nerve; (6) crural branch of genito-crural and the ilio-inguinal nerve; (7) superficial division of the obturator nerve; (8) fat, with deep lymphatic glands and vessels.

Structures beneath the Gluteus Maximus Muscle.—(1) Part of gluteus medius; (2) superficial branch of the gluteal artery and superior gluteal nerve; (3) pyriformis muscle; (4) lower border of gluteus minimus; (5) sciatic vessels; (6) great and small sciatic nerves; (7) pudic vessels and nerve; (8) nerve to the obturator internus, which also supplies the gemellus superior; (9) nerve to the quadratus femoris, which also supplies the gemellus inferior; (10) gemellus superior muscle; (11) tendon of the obturator internus; (12) gemellus inferior; (13) tendon of the obturator externus; (14) quadratus femoris; (15) termination of the internal circumflex artery; (16) part of adductor magnus; (17) the first perforating artery; (18) great trochanter, with part origin of the vastus externus; (19) the tuber ischii with the origin of the hamstrings—biceps, semi-membranosus, and semi-tendinosus; (20) great sacro-sciatic ligament pierced by the coccygeal branch of the sciatic artery; (21) three bursæ (*a*) one over the trochanter major; (*b*) one over the vastus externus; (*c*) and another over the tuberosity of the ischium. When this last one is enlarged, as by excessive pressure, it gives rise to the condition known as '**weaver's bottom**,' corresponding to '*miner's elbow*,' or '*housemaid's knee*' in other situations. The lower edge of this large muscle forms the 'fold of the buttock,' but the 'fold'

and the lower edge of the muscle do not correspond in direction, the 'fold' being nearly transverse, while the lower edge of the muscle passes upwards and inwards.

The Great Sciatic Nerve.—This nerve leaves the pelvis by the great sacro-sciatic foramen, below the pyriformis muscle, and a little external to the sciatic artery. The nerve will, therefore, be found beneath a point a little external to the point that indicates the situation of the sciatic artery on the surface of the body (see p. 123). Its course is indicated by a line drawn from the point where it emerges from the pelvis to the middle of the upper part of the popliteal space. The nerve, however, is not straight, but is curved with the convexity outwards, and at its upper part is found almost midway between the great trochanter and the tuber ischii. but a little nearer the ischium. The nerve is covered by the gluteus maximus and the long head of the biceps, and slightly by the pyriformis, and it lies upon all the muscles found beneath the gluteus maximus below the pyriformis, viz.—tendon of the obturator internus and the two gemelli, obturator externus, quadratus femoris, and adductor magnus. It is important to remember its course in connection with the operation of *acupuncture* for sciatica; further, it is important to bear in mind, in the operation of **stretching** this nerve, that it can be exposed without cutting through any muscular structure, at the lower border of the gluteus maximus, (indicated by the fold of the nates) in the interval between that muscle and the long head of the biceps. The **instruments required** are—a knife to shave the parts, carbolic oil, a scalpel, dissecting forceps, retractors, sponges, needles and horse hair

sutures, collodion, pads of cotton wool and bandages, chloroform, &c. The **Surgeon** may either stand on the same side of the body as the nerve about to be stretched, or on the opposite side.

1. At the **fold** of the buttock.—The part must first be rendered thoroughly aseptic. It is then shaved, if necessary, and an **incision** made about two inches in length in the line of the nerve; this incision divides the skin, superficial fascia, fatty tissue, and deep fascia. The finger is then introduced to hook out the nerve, which is found in the angle formed by the gluteus maximus on the inner side, and the hamstrings, as they arise from the ischial tuberosity, on the outer side. The nerve is then to be stretched as much as the Surgeon deems necessary, being first pulled well out, and then up the limb and down the limb. Some Surgeons lift the the limb from the table by the nerve. Dr SYMINGTON advises care, lest the sacral plexus be torn away from the cord. A caution is usually given not to stretch the tendon of the semi-membranosus by mistake; but by the above plan this is not likely to happen, for it would be impossible to hook that tendon *out* at the wound so near its origin, and especially when the patient's knee joint is extended. The wound is then to be washed out by some antiseptic, three sutures inserted, and the whole sealed up by flexible collodion and cotton wool. 2. It may also be stretched at the **middle of the thigh** by an incision two or three inches long, dividing the same structures as in the last case. Here the nerve lies between the biceps on the outer side, and the semi-tendinosus on the inner side. The wound may be dressed as in the last case, or it may be drained, dressed antiseptically, and confined in a splint.

for a week or ten days. 3. The 'dry' plan (TROMBETTA and BILLROTH). The patient is laid on his back, the knee joint is flexed, and the ankle joint extended, and then the thigh is forcibly flexed on the abdomen until the knee joint almost touches the chin; the thigh is then held firmly in this position while the knee joint is fully extended and the ankle joint as fully flexed.

HIP JOINT DISEASE.

It is a fact worthy of notice in connection with the conduction of nervous impulses in sensory nerves, that when a stimulus is applied to any part in the course of a sensory nerve—as to the nerve trunk, or to sensory filaments supplying parts nearer the central nervous system than the final distribution of the nerve—that the impulses appear to be conveyed to, or to spring from, its terminal filaments (in fact the sensory nerve *appears* to be able to conduct impulses *both* ways). Thus, if we compress the ulnar nerve at the elbow joint, we feel the painful impression conveyed to the terminal filaments of the nerve, supplying the little finger and the ulnar side of the fourth finger. We also find an example of the same phenomenon in connection with hip joint disease in its earlier stages; for at first the patient does not feel pain in the hip itself, but on the inner side of the knee or in the knee joint itself. This is no doubt due to fact that the obturator nerve supplies sensory filaments to both the hip and knee joints; and also because there is frequently found on the inner side of the lower third of the thigh, a plexus of nerves known as the 'obturator plexus,' which is formed by filaments from the internal cutaneous, long saphenous, and obturator nerves. Besides the obturator

nerve, the anterior crural and the great sciatic (through its branches) also supply both the hip and knee joints.

Hip disease has been divided for convenience into various stages. 1. **The inflammatory stage,** probably accompanied with some synovitis and softening of the structures round the joint, and the limb assumes that position where the cavity can hold most with the least tension. The **signs** of this stage are—(*a*) *Flexion*, as in this position there is most general relaxation, and the cavity holds most. (*b*) *Abduction*, which relaxes the outer limb of the ilio-femoral ligament. (*c*) *Eversion*, which relaxes the inner head of the same ligament. (*d*) *Apparent lengthening*, from the tilting down of the pelvis on that side; the anterior superior spine moves downwards, forwards, and inwards. This is because the flexion and the abduction raise the foot off the ground and also destroys the parallelism of the two limbs; hence, when the patient walks, to enable the foot to reach the ground and also to restore that parallelism which is necessary for walking, the pelvis tilts. (*e*) *Lordosis*, this is because the hip joint is fixed by muscles in the flexed position, and to overcome this disadvantage the lumbar vertebræ move instead, and are also curved forwards. This is well seen when the patient is laid on a firm table on his back; as he lies in this position his knee is bent upwards, and on attempting to bring the knee down level on the table the lumbar spine becomes hollow, because the *pelvis moves* with the femur. Besides these symptoms there are others, such as the limitation of abduction, wasting of the limb, flattening of the buttock, and obliteration of the gluteal fold. In the very early stage of the disease the symptoms are often

ill-marked, the child scarcely complains, and probably has only a slight limp when walking. 2. **Second stage**—This corresponds to yielding of the capsule, probably abscess formation, but no destruction of the bone. The **signs** are—(*a*) *Adduction*, some say because the posterior part of the capsule gives way, others that it is because the adductors are reflexly thrown into spasm. (*b*) *Inversion*, this is not very easily explained; if the head of the bone were dislocated backwards through the softened posterior part of the capsule, one could understand it. It may be that the external rotators are inhibited, and the internal, supplied by the superior gluteal nerve (tensor fascia femoris, gluteus minimus and anterior half of the gluteus medius) reflexly thrown into spasm. (*c*) *Apparent shortening*, this is from tilting of the pelvis so as to bring the diseased limb parallel with its fellow as the patient lies in bed. The anterior superior spine moves upwards, backwards, and outwards. 3. **Third stage.**—In this stage the limb is pretty much in the same position as in the second stage, but there is now *real shortening;* this results from the gradual destruction of the head and neck of the femur. The top of the great trochanter ascends above Nélaton's line, and there may be actual dislocation in some cases. The natural cure of this condition is by ankylosis, and care must be taken lest this occur, as it is apt to do, in the flexed and abducted position. Should it occur the effects are minimised by the production of a lumbar curve (lordosis).

DEEP FASCIA OF THE THIGH.

The deep fascia of the thigh, from its great extent, is known as the *fascia lata*. It is attached above to

the body of the pubes and pubic arch, Poupart's ligament, crest of the ilium, and margin of the sacrum and coccyx; it passes downwards, forming a complete sheath for the whole of the thigh, which varies in thickness at different parts, and is *firmly* attached below to all the prominent points around the knee joint, such as the condyles of the femur, tuberosities of the tibia, and head of fibula. After this, it forms the deep fascia of the leg, but there is no direct communication between the sheath of the muscles of the thigh and those of the leg; and, on account of this firm connection of the fascia to the bony prominences around the knee joint, fluid matter, such as pus, gathering about the joint will necessarily tend to pass upwards. At the outer side of the limb there is a specially strong band known as the *ilio-tibial band* which stretches from the ilium above to the head of the tibia below, and into which is inserted the greater part of the gluteus maximus, and the whole of the tensor fasciæ femoris, and through it these two muscles act indirectly on the knee joint, and are believed to be specially brought into use in maintaining the erect posture. From the deep surface of the fascia, ensheathing processes are given off to every muscle, blood vessel and nerve in the limb; two of the processes given off are specially strong, and are known as the inter-muscular septa. The external septum is the stronger, and extends from the insertion of the gluteus maximus along the outer side of linea aspera to the outer condyle of the femur, along the outer edge of the popliteal surface of that bone. It separates the vastus externus in front from the biceps behind. The *internal* septum is thinner, and extends from the lesser trochanter,

along the inner side of the linea aspera and popliteal surface of the femur, to the inner condyle; it separates the vastus internus from the adductor muscles, and is incomplete at one point to allow the passage of the femoral vessels into the popliteal space where they become the popliteal vessels. It is possible, therefore, that matter collecting around, or in the joint, and escaping on account of destruction of its ligaments, and collecting in the upper part of the popliteal space behind and between those layers, and beneath the general sheath of the limb, would find its way up the limb towards the trochanters, by passing along the fibrous tunnel formed by the vessels in their passage through the septum. But there is another way in which pus may pass from the knee joint up to the trochanter minor. There is a considerable portion of the inner surface of the shaft of the femur, extending from the small trochanter above, to the condyles below, and from half an inch to three-fourths of an inch in breadth, from which no muscular fibres arise. This interval lies between the origins of the crureus and the vastus internus, and is bridged over by the conjoined fibres of these muscles. In suppuration, therefore, within the joint, where the suppurative action destroys or perforates the ligaments, or the large synovial membrane of the articulation, which extends upwards beneath the extensor muscles of the thigh, the escaped pus easily finds its way up the thigh in the direction named.

CHAPTER XXXII.

THE LOWER EXTREMITY *(Continued).*

POPLITEAL SPACE.

This is a diamond-shaped cavity situated at the back of the knee joint. **Boundaries.**—(1) *External superior*, the biceps; (2) *internal superior*, semi-tendinosus, semi-membranosus, and further back the gracilis and sartorius; (3) *external inferior*, the outer head of the gastrocnemius and the plantaris; (4) *internal inferior*, the inner head of the gastrocnemius. The *roof* is formed by the popliteal fascia; the *floor* is formed by the popliteal surface of the femur, the posterior ligament of the knee joint, and the popliteus covered by its fascia. **Contents.**—(1) The small sciatic nerve; (2) the internal and external popliteal nerves and their branches; (3) the popliteal artery with its branches; (4) the popliteal vein with its tributaries, especially the external or short saphena vein; (5) the articular branch of the obturator nerve; (6) fat and areolar tissue; (7) four or five lymphatic glands, deeply placed beside the great vessels.

Division of Contracted Tendons at the Knee Joint.—To remedy the deformity of contraction of the knee joint, division of the hamstring tendons is sometimes necessary. The biceps is inserted into the head of the fibula, the other two are towards the inner side of the

joint—the semi-tendinosus being inserted into the upper part of the inner surface of the tibia, the semi-membranosus into a groove in the back of the internal tuberosity of the tibia. It is the biceps tendon, however, that most frequently requires division; and it is in the division of this tendon that the greatest care is necessary. In division of the biceps tendon, the structures that must be avoided are—(1) The external popliteal or peroneal nerve; (2) the inferior external articular artery; in connection with the other two tendons we have merely to avoid the articular arteries, which, however, are not in very close relation to the tendons in question. The external popliteal nerve passes obliquely downwards and outwards, lying *close to the tendon of the biceps*, and passes between it and the outer head of the gastrocnemius to a point below the head of the fibula, where it divides into its terminal branches. The **articular arteries** are arranged as follows:—(1) The superior internal passes round the femur, above the inner condyle, under the tendons of the *adductor magnus*, semi-membranosus, and semi-tendinosus muscles; (2) The superior external passes round just above the outer condyle *beneath the tendon of the biceps;* (3) the inferior internal passes down below the internal tuberosity of the tibia beneath the lateral ligament and the tendons of the sartorius, semi-tendinosus, and the gracilis; (4) the inferior external passes *above the head of the fibula* (and, therefore, higher up than the internal) beneath the external lateral ligament and *tendon of the biceps.* The biceps tendon is divided near its insertion into the head of the fibula; the other tendons are then put upon the stretch and also divided near their insertions. The

knife must in all cases be entered with its point directed from the middle line of the leg and close to the tendon to be divided.

Bursæ in the Region of the Knee Joint.—There are eight altogether—two in front and six behind. In **front**—(*a*) The bursa patellæ, situated in front of the patella, being the structure affected in 'housemaid's knee.' (*b*) Another bursa placed between the ligamentum patellæ and the upper part of the tubercle of the tibia. **Behind** there are six—four on the outer side and two on the inner. *Outer side*—(*a*) One between the popliteus tendon and the tibia, a prolongation of the synovial membrane of the knee joint; (*b*) one between the popliteus tendon and the external lateral ligament; (*c*) one between the biceps tendon and the external lateral ligament, over which the external popliteal nerve passes on its way round the head of the fibula; (*d*) one between the outer head of the gastrocnemius and the femur. *Inner side*—(*a*) A large bursa between the femur and the inner head of the gastrocnemius and tendon of semi-membranosus; this one very often communicates with the joint. (*b*) One between the semi-membranosus and the tibia, The ones on the *inner* side are more frequently enlarged than those on the outer side.

GENU VALGUM.

Genu-Valgum or **Knock-Knee** is a condition brought about by altered pressure relations at the two sides of the knee joint; it is low at the inner side and high at the outer, and hence the increased growth at the inner side, which is an attempt to restore the proper relations, for, like water, tension tends to find its own level. Three

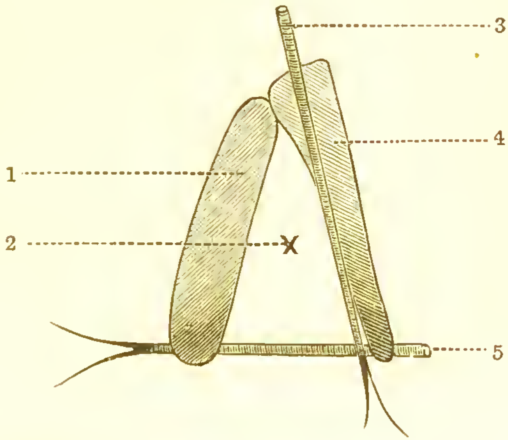
steps are usually recognised in this process—(1) Tension and elongation of the tissues at the inner side of the joint; (2) relaxation and contracture of the tissues at the outer side; (3) bony deformity; the increased growth being due to elongation of the shaft, not the epiphysis (MICULICZ). Clinically, PROFESSOR CHIENE divides cases of knock knee into two classes—(1) Those that are growing worse; (2) those where no change is going on, and the parts have become solidified permanently in the deformed position. For the first of these classes the conditions must be reversed; the pressure or tension at the inner side of the joint must be increased, while that at the outer side must be diminished. This is to be accomplished by some form of external splint, and then an elastic bandage to draw the knee towards the splint; the most important point in putting up this apparatus is to *avoid rotation of the limb.* In the second class of cases some operative form of treatment is indicated.

1. **Ogston's Operation.**—Flex the knee as fully as possible and enter a long tenotomy knife, flatwise, two or three inches above the inner condyle, and pass it forwards and outwards till its point is felt in the inter-condyloid notch; next turn the edge of the knife towards the bone, and divide the soft parts as the knife is with-drawn. Now introduce an Adam's saw, and divide the condyle for about three-quarters of its thickness; then remove the saw and forcibly straighten the limb, when the condyle is broken off and slips upward over the sawn surface. The great objection to this operation is that it opens into the knee joint. This is avoided by

2. **Chiene's Operation.**—He removes a wedge, by

means of a chisel and mallet, from the base of the inner condyle, but in such a way that the knee joint is not opened into. The instruments required for this operation are the same as in the next operation, and the part of the femur operated upon is also the same as in M'EWEN's operation. It is a small triangular-shaped muscular interval, the bone forming its floor (Fig. 53). *Anteriorly* it is bounded by the fibres of the vastus internus; *posteriorly*, by the tendon of the adductor

Fig. 53.



GENU-VALGUM TRIANGLE—RIGHT SIDE.

1. Vastus internus. 2. Floor of triangle, formed by the femur. 3. Branch of the anastomotica magna. 4. Adductor magnus. 5. Superior internal articular artery.

magnus and a branch of the anastomotica magna; and *below*, by the superior internal articular artery. The lower and posterior walls especially must be avoided during the operation lest these vessels be wounded. He removes the wedge by M'Ewen's mallet and 'chisel.' He makes an incision of sufficient length in front of and above the 'adductor tubercle,' through which he removes the wedge; the long axis of the wedge runs

downwards and outwards towards the intercondyloid notch. After its removal the limb is bent straight as in Ogston's operation.

3. **M'Ewen's Operation. — Instruments required—** (1) A long straight bistoury; (2) means to command the circulation through the limb, as Esmarch's elastic bandage and Petit's tourniquet, as the operation should be bloodless; (3) a set of osteotomes or bone chisels; (4) wooden mallet about a pound and a half in weight; (5) bag of moist sand; (6) sponges, needles, horse hair sutures, carbolic spray, &c. The limb is first rendered bloodless by Esmarch's elastic bandage and Petit's tourniquet applied above the knee. **Place of Incision.** —On the inner side of the limb at the point where the two following lines intersect—(*a*) A line drawn a finger's breadth above the level of the upper border of the *external* condyle round the limb to the inner side; and (*b*) a line drawn parallel with and half an inch in front of the tendon of the adductor magnus. At this point a longitudinal incision is made of sufficient size to readily admit the osteotome, the knife cutting at once to the bone, the knee joint being previously bent and its outer side laid on the sand bag. One assistant steadies the thigh, while another steadies the leg. *Before* withdrawing the knife, the largest 'chisel' is introduced longitudinally by its side, till it reaches the bone; the knife is then withdrawn, and the osteotome turned transversely to the long axis of the femur, but in doing so do not press too heavily upon it, lest the periosteum be stripped off the bone. By means of the mallet and chisel the bone is then divided, the operator bearing in mind that the *outer* side of the femur, in this situation, is much broader in the antero-posterior diameter than

the inner, and directing the osteotomes accordingly, and always working *away from* the popliteal artery. As the incision is carried through the bone, finer pointed osteotomes must be used till about two-thirds of the bone is divided. After each blow with the mallet the chisel must be moved a little from side to side in the longitudinal axis of the limb to prevent its point becoming fixed. After the bone is divided sufficiently, the limb is forcibly straightened. The **structures divided** in this operation are—the skin, superficial fascia, cellular tissue and fat, deep fascia, and a part of the vastus internus, periosteum and bone. No bone is *removed*, the bony tissue being simply condensed at each side of the incision made by the osteotome. The incision is above the epiphysis, so that it is not injured. The flexing of the knee carries the synovial pouch down out of the way, and besides, the mode of entering the osteotome would push it aside. The femoral artery is well out of the way; the superior internal articular runs below the line of the incision, and the anastomatica magna runs parallel with and close to the tendon of the adductor magnus, and is therefore behind the incision.

After Treatment.—A single or double long splint is applied, according as one or both knees have been operated upon; it may also be necessary to apply extension by means of the weight and pulley. There is a short shelf attached to the lower edge of the long splint opposite the knee, passing inwards, and on this the knee rests. The leg must be securely bandaged to the splint and, as usual, in knock-knee cases, care taken to avoid all twisting of the limb.

CLUB FOOT.

There are four primary varieties of this deformity—(1) Talipes varus (or, more usually, talipes equino-varus; the sole of the foot looking inwards, and the heel being usually a little raised); (2) talipes equinus (in this form the heel alone is raised); (3) talipes valgus, and, (4) talipes calcaneus. It may either be congenital or acquired, and is said to be more common in boys. It is very often a result of infantile paralysis, a disease attacking children usually about a year and nine months old.

(1) Talipes Varus.—This is the most common form of congenital club foot (or rather talipes-equino-varus, as it is rarely pure), and when it is so, usually both feet are affected, and it is frequently associated with *spina bifida*. In some cases, however, it is acquired, and, when it is so, usually only one foot is affected. In congenital cases of one foot, it is twice as often found in the right foot, and most frequently in boys; further, it is hereditary, being transmitted through the male side. *Causes*—Contraction of (*a*) tibialis anticus and posticus, (*b*) the muscles of the calf, and (*c*) the plantar fascia. *Treatment*—The treatment is division of the contracted structures; as to the *order* in which they should be divided there is considerable variety of opinion. The tendons of the tibialis anticus and posticus require great care in their division, on account of the close relation of the posterior tibial vessels, and the long saphenous vein. The tendon of the tibialis anticus passes downwards and forwards to be inserted into the *anterior* part of the internal cuneiform bone and the base of the first metatarsal; the tendon of the

tibialis posticus grooves the inner side of the posterior surface of the tibia just above the malleolus, and then passes downwards and forwards to be inserted into the tubercle of the scaphoid, and the *posterior* part of the internal cuneiform bone. The position of the tendons may be ascertained by trying to evert the foot, and thus making them tense, if not already rendered tense and evident by the deformity. The tendon of the *tibialis posticus* is divided an inch above the internal malleolus, and, in doing so, be careful to avoid wounding the posterior tibial artery which lies about a finger's breadth behind it; to save the artery, a blunt-pointed tenotomy knife should be used after the sheath has been opened by a sharp-pointed tenotome. If the division is made higher up there is more danger of dividing the flexor longus digitorum than when it is done at the point named. In this situation the tendon lies midway between the anterior and posterior borders of the leg. The *tibialis anticus* is divided on a level with the internal malleolus; the knife is passed from the outer side of the tendon to avoid the risk of wounding the dorsal artery of the foot, but on the other hand equal care must be taken not to divide the trunk of the internal or long saphena vein which lies to the inner side of the tendon in question. The plantar fascia is divided, if necessary, an inch in front of its attachment to the os calcis, as at this point it is narrowest. By leaving the division of the tendo Achillis to the last we have a fulcrum or fixed point, by which we can twist the foot into a proper position. If the division of the other structures is not sufficient, then the *tendo Achillis* must also be divided. It is divided about an inch above the os calcis, as at this point the

tendon is contracted, and further it is above the large bursa which lies between it and the upper part of the posterior surface of the os calcis. The knife is entered from the inner side to avoid the posterior tibial vessels.

(2) **Talipes Equinus.**—This form has never been known to occur as a congenital deformity. *Causes*—(*a*) Contraction of the gastrocnemius and soleus, (*b*) paralysis of the anterior group of muscles from infantile diseases, (*c*) irritation caused by worms, (*d*) nervous disturbances during teething, (*e*) abscess in the calf of the leg crippling the muscles of the calf; (*f*) flexion of the knee and extension of the ankle during the natural cure of ankle joint disease—from not keeping the knee straight and the foot at right angles to the leg. *Treatment*—Division of the tendo Achillis.

(3) **Talipes Valgus** (or more usually *calcaneo-valgus).*—In this case the foot is everted, the outer side of the foot being raised, and sometimes the heel also *(calcaneo-valgus).* In this deformity the tendency, in the first instance, is to obliteration of the arches of the foot, giving rise to flat or splay foot *(talipes planus)*, and afterwards the outer side of the foot is raised by contraction of the peronei muscles. *Causes*—(*a*) Relaxation of the ligaments supporting the plantar arches, with contraction of the peronei; (*b*) over fatigue in standing (and, therefore, likely to occur in young women in shops where the *barbarous* custom is enforced of *standing* from morning till night behind the counter, with but little intermission), and carrying heavy weights on the head, &c.; (*c*) sliding the foot in walking, or twisting it so as to press on its inner side; (*d*) it may be hysterical. *Treatment*—(*a*) Constitutional, aided by rubbing, galvanism, &c.; (*b*) if not very pro-

nounced it may be cured by adapting the sole of the boot so as to restore and support the arch of the foot; (*c*) it may be necessary to divide the peronei tendons. The *peroneus tertius* passes beneath the anterior annular ligament of the ankle joint, and is inserted into the *inner side* of the base of the fifth metatarsal bone; the *peroneus longus* lies in the groove behind the external malleolus, curves forwards and downwards on the outer side of the os calcis below the peroneal tubercle, curves inwards, lying in the groove of the cuboid, and passes to be inserted into the *outer* side of the base of the first metatarsal and internal cuneiform bones, (it is inserted into the same two bones as the *tibialis anticus*); the *peroneus brevis* also lies in the groove on the back of the lower end of the fibula, but passes along the side of the os calcis *above* the peroneal tubercle, and is inserted into the prominent tip of the fifth metatarsal bone. It is rarely necessary to divide these tendons: it will generally be found sufficient to forcibly draw the foot inwards so as to overcome the tension of the peronei, and then fixing the foot by a properly constructed splint. If, however, it be found necessary to divide them, the tendons of the peroneus longus and brevis may be divided as they lie one above the other in the groove on the back of the fibula—*i.e.*, behind the external malleolus; the tendon of the tertius may be divided near its insertion on the outer side of the dorsum of the foot by rendering it tense, and inserting a tenotomy knife between it and the skin, and dividing it in the usual manner.

(4.) Talipes Calcaneus.—In this form the toes are raised by the extensors, and the patient walks upon his heel. It is very rare to find this form congenital—

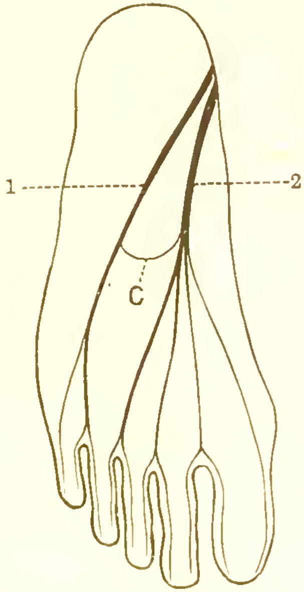
(SPENCE)—although some London Surgeons say that it is usually congenital, and very frequently associated with *spina bifida*. *Causes*—(*a*) contraction of cicatrices, following burns on the anterior aspect of the leg; (*b*) contraction of the flexor tendons of the ankle joint and the extensors of the toes (indirect flexors of the ankle joint); (*c*) paralysis or crippling of the muscles of the calf. *Treatment*—Division (if other means fail) of the tendons that pass through the anterior annular ligament —the tibialis anticus on the inner side of the foot, the peroneus tertius on the outer side (these two are *direct* flexors of the ankle joint), the extensor longus digitorum and the extensor proprius hallucis (these two are *indirect* flexors of the ankle joint). They are divided as they pass over the dorsum of the foot, and their position may be readily ascertained by rendering them tense. Care must be taken not to wound the dorsal artery of the foot, which will be found between the tendon of the extensor proprius hallucis on the tibial side, and the innermost tendon of the extensor longus digitorum on its fibular side; neither of these, however, lie close to the vessel. The anterior tibial nerve lies to the outer side of the artery.

Structures at the Ankle Joint.—For convenience we begin at the internal malleolus and pass outwards over the front of the ankle joint, and thus round the ankle. (1) Tibialis anticus muscle; (2) extensor longus hallucis; (3) anterior tibial vessels; (4) anterior tibial nerve; (5) extensor longus digitorum and peroneus tertius; (6) fibula; (7) peroneus longus, with the brevis beneath it; (8) tendo Achillis and the tendon of the plantaris; (9) flexor longus hallucis; (10) posterior tibial nerve; (11) posterior tibial artery, with its venæ

comites; (12) flexor longus digitorum; (13) tibialis posticus; (14) tibia. Of course, it is only the *tendons* of the above muscles that we find in this situation.

Synovial Membranes of the Foot and Ankle Joint.—They are seven in number: (1) one at the ankle joint proper; (2) one in the posterior calcaneo-astragaloid articulation; (3) one in the calcaneo-talo-scaphoid

Fig. 54.



PLANTAR CUTANEOUS NERVES.

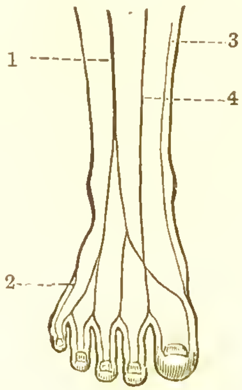
1. External plantar. 2. Internal plantar. C. Communicating branch.

articulation; (4) one between the os calcis and the cuboid bone; (5) one between the scaphoid and the three cuneiform bones, and also between the cuneiform bones themselves and the bases of the second and third metatarsal bones; (6) one between the cuboid and the bases of the fourth and fifth metatarsal bones; (7) one

between the internal cuneiform bone and the first metatarsal bone.

Nerves of the Toes.—On the **plantar** aspect (Fig. 54) the *external plantar* supplies one and a half toes (= the ulnar of hand); the *internal plantar* supplies three and a half toes (= the median nerve of the hand). On the **dorsal** aspect (Fig. 55), the *musculo-cutaneous* nerve supplies three and a half toes —all except the cleft between the first and second toes

Fig. 55.



DORSAL CUTANEOUS NERVES.

1. Musculo-cutaneous. 2. External, or short saphenous. 3. Long saphenous. 4. Anterior tibial.

and the outer side of the little toe. The *anterior tibial* supplies the cleft between the first and second toes, while the *external* or *short saphenous* nerve supplies the outer side of the little toe. The *internal* or long *saphenous* nerve may sometimes supply the inner side of the big toe, but it usually ends at the 'ball' of that toe. Can this have anything to do with the 'perforating ulcer' so frequently found in this situation, *e.g.*, in locomotor ataxia?

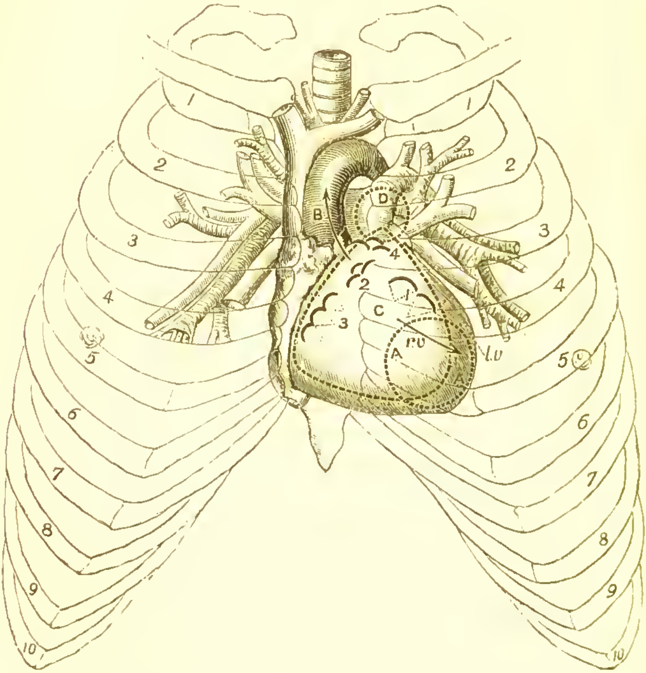
CHAPTER XXXIII.

THE CHEST AND SPINE.

Relation of the Heart to the Chest Wall.—(Fig. 56).—The *base* of the heart lies a little above the level of the third costal cartilages; a line representing it therefore would be drawn at this level, a little obliquely from right to left, and extending half an inch to the right side of the sternum, but an inch and a half to the left of the same bone. The next point to mark is the 'apex beat'; this is situated between the fifth and the sixth ribs, fully three inches to the left of the mid-sternal line (the usual stereotyped and rather loose description is—an inch and a half below, and one inch internal to the nipple). It is well to note that in all cases the 'apex beat' should be well within the 'nipple line.' The *right border* is almost entirely formed by the right auricle; to indicate it, a line must be drawn from the right end of the base line and gently curved with the convexity to the right side, to the junction of the sixth costal cartilage with the sternum. The *lower border (margo acutis)* is formed for the most part by the right ventricle, and is indicated by a line drawn from the junction of the sixth right costal cartilage with the sternum, through the xiphi-sternal articulation to the apex beat. The *left border (margo obtusis)* is formed by the left ventricle, and may be indicated by a line

drawn from the apex beat to the left extremity of the base line. The greater part of the anterior surface of the heart is formed by the right ventricle. In order to map out the cardiac dulness *(relative)* it is sufficient

Fig. 56.



To show the Relation of the Heart and Great Vessels to Chest Wall.

1. Mitral valve. 2. Aortic valve. 3. Tricuspid valve. 4. Pulmonary valve. A. Seat of the mitral murmurs. C. Seat of tricuspid murmurs. B. Seat of aortic murmurs. D. Seat of pulmonary murmurs. *r. v.* Right ventricle. *l. v.* Left ventricle.

for all practical purposes to percuss in two directions —(*a*) *vertically*, an inch to the left of the sternum, in order to avoid the aorta, and (*b*) *transversely* at the level of the fourth rib.

Cardiac 'Areas.'—The four valves of the heart, in relation to the chest wall, are situated very close to one another, round about the junction of the third left costal cartilage with the sternum and the space below it, so close that, according to WALSHE, an area of half an inch square will include a part of all four. It will, therefore, be at once evident to any one that it would be impossible, in diseased conditions of the valves, by listening over them to detect with certainty, which of the four is at fault. But the murmurs are conducted (*a*) principally by the blood stream, but also by (*b*) the bones of the chest wall, and advantage is taken of this fact to differentiate the sounds produced by the several valves. The points on the chest wall, where the sounds are best heard, are known as the '*areas*,' but do not necessarily correspond to the position of the valves producing the sounds. 1. The **mitral area** corresponds to the apex beat, and it is here that we listen for murmurs produced by the mitral valve (left auriculo-ventricular valve). 2. The **aortic area** is at the junction of the second right costal cartilage with the sternum; here we listen for murmurs produced by the semi-lunar valves of the aortic opening, as at this point the aorta comes nearest the surface of the chest wall. 3. The **pulmonary area** corresponds to the junction of the third left costal cartilage with the sternum, or the space immediately above it; the pulmonary opening is of all the openings at the base of the heart the one nearest the surface, and its 'area' therefore corresponds pretty closely with the actual position of its valve. 4. The **tricuspid area**. This is a large area, almost the whole of the anterior surface of the right ventricle of the heart, though murmurs are best heard at the left border

of the lower part of the sternum at the level of the fourth, fifth, and sixth left costal cartilages. But even when we have found out the **seat of the maximum intensity** of any murmur (endocardial), in the cardiac region, that alone is not by any means sufficient to enable us to give an exact diagnosis; for this purpose we require, in addition to find out other two points, (*a*) the **time** of the murmur, which is done by placing a finger on the apex beat itself, or else on the common carotid (the radial pulse is too far away), when we know that the impulse in the vessel corresponds to the cardiac *systole;* and (*b*) its **propogation**. These points, however, are fully discussed in works on medical diagnosis.

For the purpose of finding the cardiac areas, and many other important points about the chest, it is, of course, very important that the student should be able to **count the ribs** easily and with certainty. It is sometimes a little difficult to be quite sure of the position of the first rib, especially in stout persons; but if the student will bear in mind that there is always a fairly well marked ridge on the front of the sternum at the junction of the first and second pieces, and that this corresponds with the level of the *second rib*, he will find no difficulty whatever.

Relation of Lungs and Pleura to the Chest Wall.—The apices of the lungs extend up into the neck about an inch and a half above the clavicle; and the lower attachment of the *pleura* may be regarded as about an inch and a half from the lower border of the arch formed by the costal cartilages. The anterior margins of the lungs and pleural sacs approach each other at the level of the *second* piece of the sternum, the first

piece being almost destitute of any pleural attachment; the right pleural sac extends a little across the mid-line of the sternum, and maintains that position all the way down; the left pleural sac passes a little further down than the right, probably from the lower level of the diaphragm; it is important to keep this in mind in operations on the left kidney. From the second piece of the sternum the anterior margins pass downwards, parallel with each other, as far as the level of the fourth costal cartilage, at which point the left margin curves outwards to leave room for the heart, a part of the anterior surface of which is in this way left uncovered (the *absolute* cardiac dullness). The anterior edge of the right lung continues straight downwards as far as the sixth costal cartilage, where it joins the inferior margin. Under ordinary conditions the *lower margins* reach to the sixth rib at the sternal border, to the seventh in the mammary line, to the eighth at the mid-axillary line, to the ninth in the scapular line, and the eleventh at the vertebral column—roughly, therefore, the levels at front, sides, and back, may be taken as the sixth, eighth, and tenth ribs. The lower edges of the lungs vary much with the respiratory movements; there may be a difference in level of three inches between full expiration and full inspiration.

FRACTURE OF THE RIBS.

The two upper and the two lower ribs are rarely fractured—the upper two being protected by the clavicle, while the mobility of the lower two renders their fracture less likely. The ribs may be fractured (1) by direct violence; (2) by indirect violence, as from

pressure in a crowd, etc.; (3) muscular action during parturition. In *indirect* violence they usually give way at the angle, or near it, or at their junction with the cartilages; in *direct* violence at the part struck. The great danger in fracture of the ribs is injury to the pleura and lungs from sharp fragments projecting inwards, but this is far more likely to occur in fracture due to *direct* violence than in fracture due to *indirect* violence. In simple fracture there will be difficulty in respiration which soon becomes abdominal, and crepitus may be detected either by placing the hand over the fractured part and directing the patient to take a deep breath, or by applying the stethoscope. A valuable means of diagnosis is by indirect pressure: the Surgeon places one hand on the sternum and the other on the spine, and, on pressing gently, the patient complains of pain at the seat of the fracture; or the rib which is believed to be broken may be followed towards the spine or sternum as the case may be, and when at some distance from the fractured point, pressure is made upon the rib, when the patient will feel pain at the seat of the fracture. This will serve to distinguish it from a bruise, which after all is of little *practical* importance, as the treatment is the same in both cases.

If the lung tissue be much injured there will be expectoration of blood mixed with air, and a *constant hacking cough* from irritation of the pulmonary branches of the vagus nerve, as the most prominent symptoms. The chief *complications* likely to arise from wounds of the lung are—(1) Bleeding, especially internal, giving rise to *hæmothorax*, and leading to compression of the lung and dyspnœa; (2) *emphysema*, an infiltration of air

into the cellular tissue, indicated by puffy swelling and crackling when pressed upon; (3) *pneumothorax*, an accumulation of air in the pleural cavity; (4) *hydrothorax*, an accumulation of serous fluid in the pleural cavity; (5) suppuration and accumulation of pus in the pleural cavity *(empyema)*; (6) there is always a risk of pleurisy and pneumonia; (7) the intercostal artery is sometimes ruptured, so that there is hæmorrhage into the cellular tissue.

Treatment.—When only one or two ribs are broken the side of the chest should be strapped with plaster. Each strip should be about an inch and a half wide, and long enough to reach about two inches beyond the middle line in front and behind. They may either be applied parallel with each other, and partially overlapping, or they may be crossed in an ×-like fashion over the seat of the fracture; they should be applied during expiration, as the object is not so much to steady the fractured ends, but to rest that half of the chest and relieve the patient of pain, for there is no danger whatever of non-union, as in fractures of the shafts of long bones generally, and where splints are used chiefly to avoid this. Over all is placed a broad flannel bandage. During the process of healing of a rib, on account of the almost *constant* movement there is a good deal of ensheathing callus thrown out; the period of union is about three weeks.

PARACENTESIS THORACIS.

This is an operation for the removal of serous or purulent fluid from the chest. It is best performed with a pneumatic aspirator, and the point chosen for the introduction of the needle is either in the fifth or

sixth intercostal spaces, at the line of the insertion of the serratus magnus—that is, about midway between the sternum and the angles of the ribs, or in the seventh or eighth spaces in a line with the inferior angle of the scapula. The needle is pushed into the chest, close to the edge of the *lower* rib of the space in which it is performed, to avoid wounding the intercostal artery, which lies near the lower border of the *upper* rib. Thus, suppose the operation is performed in the fifth intercostal space, the trochar is pushed over the upper edge of the *sixth* rib. But from the mid-axillary line onwards there is an artery at each border of the space, and, therefore, it should be entered through the middle of the space, and during inspiration, as the space during this act is widened. It is necessary to thrust in the needle with considerable force, so as to make sure of its piercing the pleura, which is usually thickened; otherwise it might simply drive the thickened pleura before it. In *hydrops pericardii* the pericardium may be tapped in the fifth intercostal space, in the cardiac region, in the same manner; the point of the greatest accumulation of fluid being determined by percussion. A *very* fine needle must be employed, and the fluid drawn off very slowly.

EXCISION OF THE MAMMA.

This is most frequently required for the removal of malignant tumours—cancer or sarcoma. In performing this operation for malignant disease, the Surgeon must cut wide of the disease so as to give a good wide atmosphere of healthy skin; the whole of the gland tissue, together with the nipple, must also be removed, and at the present day most Surgeons believe that the

axilla should be cleared out at the same time, whether the glands are visibly affected or not—a procedure advocated and practised by LISTER many years ago. The **instruments required** are:—A large straight broad-bladed bistoury, a scalpel, dissecting forceps, a large number of Wells's or Péan's forceps, blunt hooks, retractors, horse hair sutures, catgut ligatures, two or three silver wire button sutures, sponges, scissors, drainage tubes, needles, dressing forceps or sinus forceps, bandage to secure the arms, tenaculum, chloroform, and the usual dressings. The **patient** is laid upon her back, her head and shoulders resting on a pillow, the arm of the affected side hanging over the side of the table, tied down or held by an assistant, so as to put the pectoralis major on the stretch; when the axilla is being cleared out the assistant must draw the arm vertically upwards, parallel with the side of the patient's head. The **operator** must stand on the same side as the breast to be removed.

The Operation.—The whole breast, side, and axilla should be well washed with carbolic lotion, 1 in 20. Two elliptical **incisions** are then carried round, above and below the nipple, parallel with the fibres of the pectoralis major, as otherwise the edges of the wound might gape. The incisions must at once pass through the skin and fascia, and many Surgeons advise that the lower incision should be made first, so that the parts may not be obscured by blood, as they are apt to be when the upper is made first. All bleeding vessels must be tied or twisted as the operation proceeds, or else secured by catch forceps. In cases, however, where the Surgeon has determined beforehand to clear out the axilla, the incisions are often made transversely to

the trunk, and from their point of union below, an incision is prolonged to the posterior border of the axilla; in addition, another incision is prolonged upwards along the anterior border of the axilla as far as may be deemed necessary, in order to thoroughly explore the axilla. By means of these incisions the glands and fat of the axilla may be completely elcared out; the position of the different sets of glands must be kept in mind (see p. 568), especially those glands along the lower border of the pectoralis major. Great care is necessary in performing this part of the operation, especially when working towards the outer and posterior walls of the axilla, chiefly because of the presence of the large subscapular vessels—the vein, from the risk of air being sucked in, and also because the vessel is kept open by the dense fascia surrounding it; the artery, because of its large size and the difficulty of securing it. This is specially the case should they happen to be cut near the main trunks, for then by their retraction and contraction the accident becomes equivalent to a wound of the axillary artery or vein; a similar accident may happen from the injudicious use of the fingers, whereby some small vein is torn close to the main trunk. If the opening in the axillary vein is small, simply pinch it up and apply a ligature without including the whole circumference, but if large, the entire vessel must be surrounded on each side of the opening. The arteries divided in this operation are chiefly the perforating arteries from the internal mammary, the long thoracic or external mammary, as well as the short and alar thoracics and branches of the subscapular.

The arm is now to be brought to the side, and the wound

closed. Drainage tubes should be introduced at the lower angle of the incision, and if this is not the *lowest part of the wound*, then another special opening must be made at the very lowest part by the dressing forceps and scalpel, after HILTON's method of opening abscesses, and a tube introduced there also. To bring the edges of the wound together it will in all probability be necessary to introduce two or three silver wire 'button sutures,' then several deep horse hair (double hairs) sutures (*'sutures of support'*), and lastly, a number of finer horse hair (single hair) sutures to bring the skin edges accurately into apposition (*'sutures of apposition'*). In tying horse hair sutures it is better to put the first knot twice through to prevent it slipping; in introducing the superficial sutures carefully avoid any inturning of the lips of the wound. Protective is then placed over the wound, and over the buttons, and then a large amount of antiseptic wool, the arm being brought close to the side, and the forearm laid across the chest, with the hand pointing to the opposite shoulder; it is then to be firmly bandaged to the side, somewhat after the manner of treating fractured clavicle. The dressings will require to be changed within the first four-and-twenty hours.

THE SPINE.

At the upper part of the spine we find the **Sub-occipital triangle**; it is situated just below the occipital bone, and has the following **boundaries**—*Above*, the superior oblique; *below*, the inferior oblique; *behind*, the rectus capitis posticus major; the *roof* is formed by the complexus; and the *floor* is formed by the posterior occipito-atloid ligament and

posterior arch of the atlas. The **contents** are—(1) The vertebral artery; (2) the suboccipital nerve; and (3) anastomoses between the deep cervical, princeps cervicis, and the vertebral. To **expose** this triangle the following muscles must be reflected:—(1) trapezius; (2) sterno-cleido-mastoid; (3) complexus; (4) splenius capitis; and (5) the trachelo-mastoid.

Muscles Between the First and Second Vertebræ and the Occipital Bone.—1. Between the **atlas and the occipital bone**—(1) The rectus capitis posticus minor; this muscle *arises* from the posterior tubercle of the atlas, and is inserted into the occipital bone. (2) The superior oblique; it *arises* from the transverse process of the atlas, and is *inserted* into the occipital bone. (3) The rectus capitis lateralis; it *arises* from the upper surface of the transverse process of the atlas, and is *inserted* into the jugular process of the occipital bone. (4) The rectus capitis anticus minor; it *arises* from the front of the lateral mass of the atlas, and is *inserted* into the occipital bone.

2. **Between the Axis and the Occipital Bone.**—The rectus capitis posticus major; this muscle *arises* from the spinous process of the axis, and is *inserted* into the occipital bone.

3. **Between the Atlas and the Axis.**—The inferior oblique; this muscle *arises* from the spinous process of the axis, and is *inserted* into the transverse process of the atlas. It is this muscle that is chiefly concerned in the rotatory movements of the head on the top of the spinal column. The *nodding* movements of the head take place at the joint between the atlas and the occipital bone; the *rotatory* at the joint between the atlas and the axis. In a patient, therefore, with sup-

posed disease of the cervical vertebræ, if he can nod and rotate his head freely, this at least excludes disease of the *upper* two or three vertebræ.

FRACTURE-DISLOCATION OF THE SPINE.

In dislocation of the first vertebra from the second, or in fracture of the odontoid process, the patient will necessarily die at once, or at the latest in but a few minutes, as the odontoid process, or else the arch of the axis presses on the medulla, destroying the respiratory and cardiac centres. So also any fracture-dislocation above the origin of the phrenic nerves (chiefly from the fourth and fifth) the patient usually dies in a few minutes. Below this point, say between the fifth and the sixth, or the sixth and the seventh, the patient may live a few days, but with everything below the injured point paralysed—arm, leg, abdominal muscles, bladder and bowel, &c., though at the same time the intellect remains clear. The breathing is entirely diaphragmatic, and is rapid, but this is not sufficient to maintain life, and the patient gradually dies comatose, and the lungs after death are found congested and markedly œdematous. In fracture-dislocation of the lower dorsal region, the prognosis is fairly good, provided the patient can be kept alive; there is usually a considerable improvement in from six months to two years. The chief points to be attended to are careful nursing to avoid bedsores (often *acute* or *trophic*), and special attention to the bladder and bowels, drawing off the urine at least twice a day. At first there is usually retention of urine, from paralysis of the *detrusor centre*, or else from some want of co-ordination between the higher and lower centres; but

this condition, in the course of two or three weeks, gradually passes into complete incontinence, probably from the destruction of the centre for the sphincter which may or may not be recovered from. In the case of the rectum there is at first involuntary passage of its contents, but by-and-by the centre regains itself (being in the first instance paralysed from '*shock*.') It is a curious fact that in cases of complete or partial recovery the centre for the bowel seems to regain its function sooner than the bladder centres; it is common enough for the bowel to recover itself, even though the urinary centres are still deranged, and may remain so till the end of life. It is probably because the process is a less complex one, and comes to be performed in a purely reflex manner, with little or no help from the brain centre. But with urination it is different; this, apparently, can rarely, if ever, come to be perfectly performed reflexly.

The **cord itself** may suffer in a variety of ways—(1) It may simply suffer from the primary 'shock' or concussion, the effects of which pass off in a little, although the prognosis should be guarded. (2) There may be reactionary hæmorrhage within the first two days, causing high temperature, pain, and paralysis from pressure. (3) At the end of ten days or a fortnight the symptoms of inflammation may show themselves—fever, severe shooting pains along the course of the spinal nerves, rigidity, and spasm—from irritation of the motor and sensory nerves. (4) The symptoms of the immediate shock may pass off, leaving but little apparent ill effects, but slow ascending and descending degenerative changes may follow—even more to be

dreaded than anything else—which will ultimately carry off the patient.

SPINA BIFIDA.

This has been defined as a congenital hernia of the spinal membranes through a fissure in the walls of the canal ; it is most frequently situated at the lower part of the vertebral column, where it forms a rounded tumour lying in the middle line of the back, fluctuating, and may be transparent, and adhering to the bones of the column. It may be possible to feel the hole in the canal and the absence of the spinous processes of the vertebræ in that situation ; it may be partially reducible with the production of nervous symptoms. It is often associated with paralysis of the limbs, sphincters or with convulsions; also with club foot (especially talipes, equino-varus) and hydrocephalus.

To understand its mode of origin it will be necessary to refer to the development of a typical vertebra. There are *three* primary centres—one for the body, which appears about the eighth week of fœtal life, and one for each lamina which appears about the sixth week ; the *secondary* centres for the processes and upper and lower surfaces of the body do not concern us at present. The laminæ should unite behind during the first year of extra-uterine life, and the ossification *begins above* and passes downwards, so that naturally the lower dorsal and sacral lamina are the last to close, and it is exactly in this situation that spina bifida is most frequently found.

Varieties of Spina Bifida.—1. **Spinal meningocele,** where the membranes of the cord alone protrude, forming a sac filled with cerebro-spinal fluid. 2. **Meningo-**

myelocele, where the sac is formed, not only by the membranes, but by the nerve roots, and even part of the cord itself. This is the most common form. 3. **Syringo-myelocele.**—In this form the membranes also form part of the sac wall, but the chief feature is that the central canal of the cord itself is dilated to form the sac as well—the inner lining of the sac being formed by the expanded and atrophied substance of the cord. In this case, therefore, not only are the bodies of the vertebræ deficient, but the dorsal laminæ themselves, which bound the original neural or cerebro-spinal groove, have not united either at the point in question. In the case or meningo-myelocele (the common form) it is often possible to trace a median furrow on the sac wall, or detect an 'umbilicus'; this indicates the point at which the cord joins the wall of the sac.

Treatment.—As in other forms of congenital hernia, the cure is often spontaneous, and, therefore, it is advisable to wait for a few months before doing anything. In cases where the tumour is large and threatening to burst, tapping, followed by pressure, has occasionally cured the condition. Ligature and excision of the sac has been tried, but usually with a fatal result.

Morton's Method.—This seems to be the most successful and safest mode of treatment yet discovered. About half the fluid in the sac is withdrawn by a small trochar, introduced at the upper part, and in such a way as to avoid large veins and nerves, which can best be done by examining the swelling in a dark room by transmitted light; it will also be better to make the trochar traverse sound tissue for some little distance before its point enters the sac. A syringe is then filled

with Morton's Solution and emptied into the sac through the canula. The quantity injected will necessarily vary according to the size of the tumour, but half a drachm may be taken as the average. As the canula is removed the edges of the wound must be grasped to prevent the entrance of air, and the opening then sealed up with flexible collodion and cotton wool.

Morton's Solution.—Iodine ten grains, and potassii iodidi thirty grains, to an ounce of glycerine.

CLEFT STERNUM.

The four pieces forming the body of the sternum are usually developed from a single median centre for each piece; occasionally, however, the lower two or three pieces of the body are developed from two centres each placed laterally. Sometimes the lateral centres fail to unite, giving rise to a condition known as *sternal fissure* where there is a narrow slit left, or *sternal foramen* where there is a larger hole left between the pieces.

CHAPTER XXXIV.

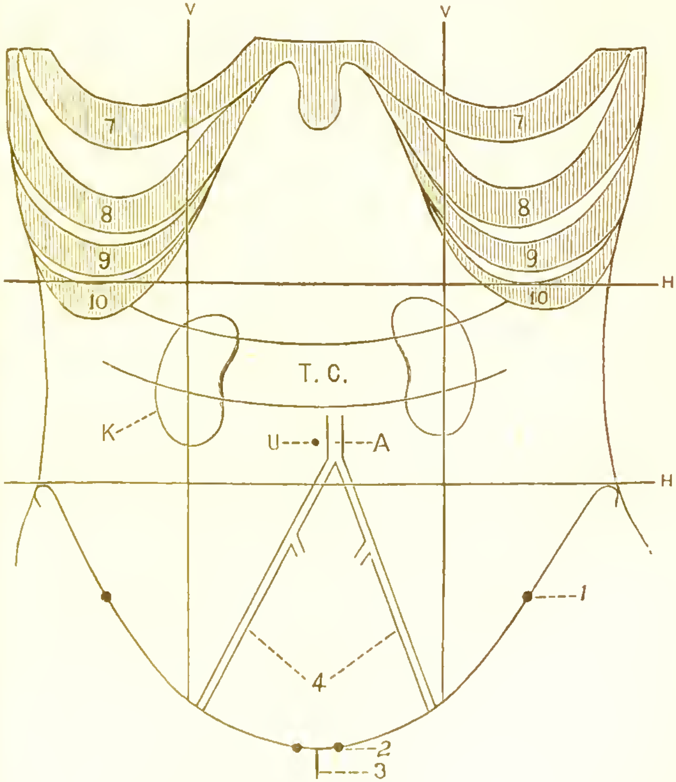
ABDOMEN.

Regions.—It is subdivided into nine regions by means of two vertical and two horizontal lines (Fig. 57). The *two horizontal lines* are drawn, one at the level of the ninth costal cartilages, the other at the level of the highest points of the iliac crests—some say the anterior superior iliac spines. The *two vertical lines* are drawn, one on each side, from the cartilage of the eighth rib to the centre of Poupart's ligament, so that they shall be parallel with the middle line of the body. The *upper* three regions are called—(*a*) Right hypochondriac; (*b*) epigastric; (*c*) left hypochondriac: the *middle* three are called—(*a*) Right lumbar; (*b*) umbilical; and (c) left lumbar: the *lower* three are called —(*a*) Right iliac; (*b*) hypogastric; and (*c*) left iliac. This will be more easily remembered by a simple arrangement like the following:—

Right Hypochondriac.	Epigastric.	Left Hypochondriac.
Right Lumbar.	Umbilical.	Left Lumbar.
Right Iliac.	Hypogastric.	Left Iliac.

Rectus Muscle.—This is a broad, flat muscle which stretches between the chest and the pubes on each side of the linea alba. It *arises* by two heads, the larger from the crest of the pubes, the other from the liga-

Fig. 57.



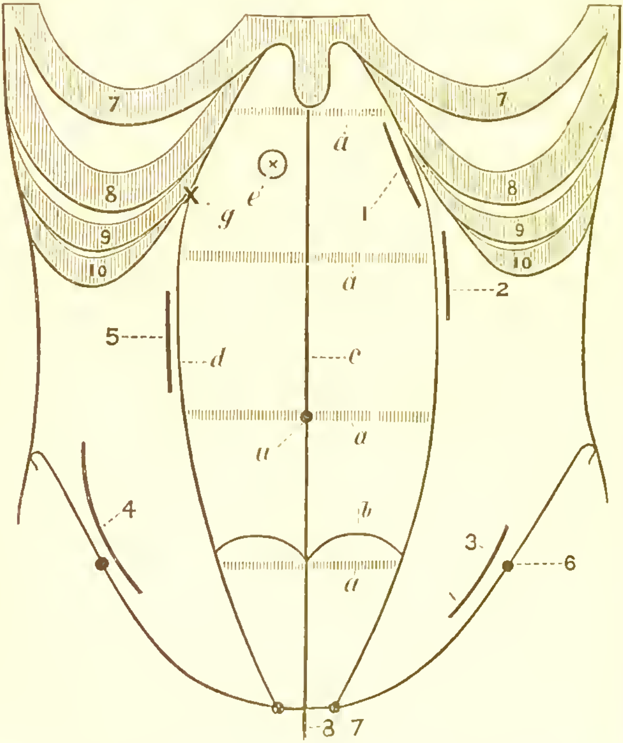
ANTERIOR ABDOMINAL WALL.

1. Anterior superior spine. 2. Spine of the pubes. 3. Symphysis pubis. 4. External iliacs. A. Abdominal aorta. U. Umbilicus. K. Kidney. T. C. Transverse colon. V. V. Vertical lines. H. H. Horizontal lines.

ments in front of the symphysis pubis. It is *inserted* into the anterior surface of the fifth, sixth, and seventh ribs.

Linea Transversæ.—These are irregular tendinous intersections which divide up the rectus into several

Fig. 58.



ANTERIOR ABDOMINAL WALL.

1. Incision for opening into the stomach. 2. Incision for operations on the spleen. 3. Incision for ligature of the external iliac. 4. Incision for ligature of the common iliac. 5. Incision to reach the kidney from the front. 6. Anterior superior iliac spine. 7. Spine of pubes. 8. Symphysis pubis. *a. a. a. a.* Linea transversæ. *b.* Position of the 'fold of Douglas.' *c.* Linea alba. *d.* Right linea semilunaris. *e.* Situation of the pylorus. *g.* Situation of the fundus of the gall bladder. *u.* Umbilicus.

segments. They are usually three in number, and are situated—one at the level of the umbilicus, a second

opposite the ensiform cartilage, and a third midway between these two; a fourth is *sometimes* found midway between the umbilicus and the symphysis pubis (Fig. 58, *a*.). These intersections are closely adherent to and blend with the *anterior* part of the sheath, but have no attachment behind.

Sheath of the Rectus.—The rectus is entirely enveloped in a fibrous sheath, except at the very upper part, where the muscle rests on the costal cartilages, and at the lower part, from a point midway between the umbilicus and the symphysis pubis, where it rests on the transversalis fascia. The sheath is formed by the

Fig. 59.

SHEATH OF RECTUS.

1. External oblique. 2. Internal oblique. 3. Transversalis. 4. Fascia transversalis. The formation of the lower part of the sheath of the rectus is here exhibited. The dotted line represents the peritoneum.—From CUNNINGHAM'S *Abdomen*.

splitting of the aponeurosis of the internal oblique muscle of the abdomen, one half passing in front, the other behind the muscle. From the ensiform cartilage to a point midway between the umbilicus and the symphysis pubis, the anterior half is joined by the aponeurosis of the external oblique, the posterior half by the aponeurosis of the transversalis muscle; hence, at this part of its course, the sheath consists of a layer and a half in front of the muscle, and a layer and a half behind (Fig. 60). But from the point above indicated to the symphysis pubis, all the three layers pass in front of the rectus, and the muscle rests behind

on the transversalis fascia (Fig. 59). The lower free margin of the posterior lamella usually presents a sharp, semi-lunar edge, with the concavity towards the pubes; this corresponds, of course, to the point where all the layers pass to the front of the muscle, and is known as the *semi-lunar fold of Douglas.* **Contents of the sheath.**—(1) The rectus muscle; (2) the pyramidalis muscle; (3) the terminal twigs of the six lower intercostal nerves and the last dorsal nerve; (4) the superior epigastric artery (one of the terminal branches of the internal mammary); (5) the deep epigastric artery. This vessel at first lies in the fat, between the peritoneum and the fascia transversalis, then piercing the fascia, enters the sheath of the rectus by passing in front of the fold of Douglas.

The Linea Semilunaris (Fig. 58, *d.*).—This is a curved line at the outer edge of the recti muscles, and corresponds therefore to the line along which the aponeurosis of the internal oblique muscle splits to enclose the rectus. It may be defined as a slightly curved line drawn from the tip of the ninth costal cartilage to the pubic spine.

The Linea Alba (Fig. 58, *c.*).—This is marked on the surface of a slight depression in the middle line of the abdomen. It is a dense fibrous cord, passing downwards from the ensiform cartilage to the symphysis pubis; it is formed by the union and interlacing of the aponeuroses of the two oblique and transversalis muscles of opposite sides. At this point, therefore, the wall of the abdomen is thin and devoid of muscular tissue and blood-vessels; it is chosen, therefore, in many operations as the best place at which to enter the abdomen, as ovariotomy, laparotomy, supra-pubic lithotomy, and paracentesis abdominis.

THE STOMACH.

Three-fourths of this organ are placed in the left hypochondriac region, the remaining fourth in the epigastric region. The long axis of the hypochondriac part is almost vertical, the great fundus being the highest part of the organ, and not the œsophageal opening, as sometimes stated; the epigastric part is transverse in direction, and is placed about two or three inches below the ensiform cartilage. When the stomach is empty the pylorus lies just to the right of the middle line (Fig. 58, *e.*); but, when distended, the pylorus moves considerably to the right of this line, and the great curvature tilts forwards and upwards. The cardiac orifice is placed behind the seventh costal cartilage, about an inch from the left border of the sternum; the fundus reaches a little above and behind the 'apex beat,' and it is easily understood, therefore, how an over-full stomach may interfere with the motions of the heart.

Relations.—In *front* we find the anterior abdominal wall, the diaphragm, and the under surface of the liver; *behind*, the crura of the diaphragm, the aorta, the pancreas, the splenic artery and vein, the superior mesenteric artery, the third part of the duodenum, the left kidney and supra-renal capsule, and the spleen with the gastro-splenic omentum. *Above*, we find the lesser omentum with its contents and the cœlic axis; *below*, the great omentum and the transverse colon. Its **peritoneal connections** are—(*a*) The gastro-phrenic ligament, passing from the diaphragm to the angle between the œsophagus and the cardiac end; (*b*) the gastro-hepatic, or

lesser omentum; (*c*) the gastro-colic, or great omentum; (*d*) the gastro-splenic omentum.

Gastrotomy—an opening of a temporary character made into the stomach for the purpose of removing a foreign body. **Gastrostomy**—an opening made into the stomach for the purpose of feeding the patient, and to establish a permanent gastric fistula. Operations of this nature may be rendered necessary in consequence of impermeable stricture of the œsophagus, to prevent the patient dying of starvation. There are three varieties of stricture—(1) The nervous or spasmodic—this form is usually intermittent, and if the patient can be induced to forget about it for the time being, the food passes quite easily; (2) fibrous stricture, the result of swallowing corrosive fluids and boiling water—this form may be dilated by passing bougies; (3) cancerous—this is the most common form. The bougie seems to pass over a *roughened* surface, and its introduction is followed by the coughing up of blood, or blood and pus; the cervical glands will also probably be enlarged, and other signs of the 'cancerous cachexia' present. By these means it may be diagnosed from fibrous stricture, and this will also be assisted by the history of the case. Malignant disease is usually of the nature of squamous celled epithelioma (the so-called 'scirrhus'), and is most frequently found opposite the cricoid cartilage (at the beginning of the œsophagus), next at the cardiac orifice, and, lastly, opposite the bifurcation of the trachea. As long as possible the patient may be fed with slops, or through a catheter, or by the use of artificially digested foods per rectum, and, if these are not sufficient, the stomach may be opened. Another possible condition must always present itself to the

student's mind, in connection with the diagnosis of stricture of the œsophagus, viz., aneurism of the aorta; *this condition must always be excluded before attempting to pass bougies.*

The patient is laid on his back, and, according to Sédillot, a **crucial incision**—each limb of which is about one inch and a half in length—should be made on the left side, two finger's breadths to the inner side of the costal cartilages, and one-third nearer the ensiform cartilage than the umbilicus. This form of incision is rarely used at the present time. The space where the opening should be made is bounded on the left side by the eighth, ninth, and tenth ribs—above and internally, by the liver; and below, by a line drawn at the level of the tenth costal cartilages. An **incision** made parallel with, and one or two finger's breadths from the costal margin, beginning at the sternal extremity of the seventh intercostal space, and carrying it downwards and outwards from two to four inches, is a form frequently used (Fig. 58, 1). Labbé contents himself with an incision in this position about an inch and a quarter or an inch and a half in length. Howse prefers a vertical incision, nearly at the same level, passing through the outer fibres of the rectus muscle, which will, it is hoped, afterwards act as a sphincter to the opening. The opening may also be made through the left linea semilunaris, or beyond this, passing through the three flat muscles of the abdomen. The **instruments required** are—Scalpel, dissecting forceps, probe-pointed bistoury, directors, plenty of Wells's forceps, broad copper retractors, blunt hooks, needles and silk, sponges, scissors, chloroform, a silver tube, &c. By some one of the foregoing incisions

the abdominal wall is cut through, and when all bleeding vessels are secured, the peritoneal cavity is opened and the stomach grasped and drawn out into the opening. Care must be taken not to mistake the transverse colon for the stomach; but the colon is distinguished by—(*a*) Its sacculi; (*b*) longitudinal bands of muscular fibres; and (*c*) by the appendices epiploïcæ. Having found the proper viscus, the next step is to secure it to the edges of the opening. This is best done by carbolised silk sutures passed through the serous and muscular coats only; the loosely attached mucous coat can readily be shaken away by grasping the other coats between the finger and thumb. The sutures are passed through the wall of the stomach, then through the divided peritoneum, and, lastly, through the skin and fat; the muscular tissue of the abdominal wall is not included. Some prefer to use a double circle of closely set silk sutures, the inner circle simply passing through the serous coat of the stomach. All the sutures are passed before any are tied; they are about one-sixth of an inch apart, and should enclose a circular area of the stomach wall about the size of a shilling. Thus secured, the wound is dressed antiseptically in the usual manner, and the patient fed per rectum for a period of from three to five days; by this time the stomach will have adhered to the wound. The third step of the operation is to make a small opening into the stomach, which is done by passing a narrow sharp-pointed bistoury through the middle of the adherent area; the opening should only be large enough to admit a No. 10 catheter. Into this opening an india-rubber or silver tracheotomy tube can be fitted. The sutures should not be removed for ten days. The

great risk of this operation is peritonitis; but by the proper use of antiseptics and the adoption of the method of doing the operation in *two* stages introduced, we believe, by Mr Howse, the risk is reduced to a minimum.

The **structures divided** will necessarily vary with the incision used. In this situation the abdominal wall is composed of the following structures:—(1) Skin and fascia; (2) the external oblique; (3) the internal oblique; and (4) transversalis muscles; (5) transversalis fascia; (6) extra-peritoneal fat; (7) the peritoneum; then comes (8) the stomach wall itself; more internally we simply find the rectus in its sheath.

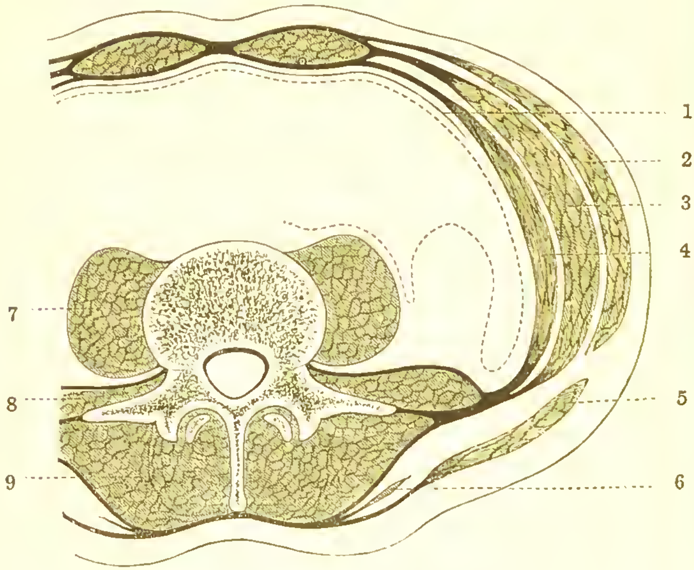
Difficulty in swallowing *(dysphagia)* may arise from other causes than stricture, such as—(1) Tumours in the pharynx, such as polypi or abscess; (2) œdema about the back of the epiglottis; (3) tumours in the neck outside the œsophagus; (4) aneurism of the innominate artery; (5) aneurism of the aorta; (6) dislocation of the sternal end of the clavicle backwards; (7) impaction of a foreign body in the gullet; (8) inter-thoracic tumours, such as enlarged bronchial glands, cancerous masses, etc. These tumours must be carefully distinguished from aneurisms. In aneurism there is dullness on percussion, dyspnœa, dysphagia, a fixed gnawing pain between the shoulders, shooting pains down the arms or side of head, and distension of the superficial veins of the chest.

COLOTOMY.

Posterior Abdominal Wall (Fig. 60).—The posterior abdominal wall (between the last rib and the iliac crest) is formed by two large muscles and the *fascia lumborum*,

or the posterior abdominal aponeurosis. The fascia lumborum is formed thus—The aponeurosis of the transversalis muscle splits into three layers, one is attached to the roots of the transverse processes of the lumbar vertebræ, a second is attached to the tips of the transverse processes, (between these two layers the

Fig. 60.



ABDOMINAL WALLS.

1. Fascia transversalis. 2. External oblique. 3. Internal oblique. 4. Transversalis. 5. Latissmus dorsi. 6. Serratus posticus inferior. 7. Psoas. 8. Quadratus lumborum. 9. Erector spinæ. The dotted line represents the peritoneum. In front the mode of formation of the upper part of the sheath of the rectus is shown.—From CUNNINGHAM'S *Abdomen.*

quadratus lumborum is situated,) a third passes to the tips of the spinous processes of the vertebræ, and between this and the second layer, the erector spinæ is placed. These three layers are also known as the anterior, middle, and posterior layers of the lumbar aponeurosis; but, in

addition, however, to these structures, there is attached to the posterior layer of this aponeurosis the tendons of origin of other three muscles, and through it these muscles may be said to arise from the tips of the transverse processes. The muscles are—(1) The latissimus dorsi; (2) the serratus posticus inferior; and (3) the internal oblique. By this means the strong fascia lumborum is formed, which protects the part below the ribs, a part which, in the skeleton, seems very weak. In this region we find the 'triangle of Petit' (Fig. 61, 10). It is bounded in *front* by the posterior edge of the external oblique; *behind*, by the anterior edge of the latissimus dorsi. The *base* is formed by the crest of the ilium (about its middle third), while the *apex* is formed by the crossing of the above two muscles. In connection with the subject of colotomy, it will be well to say a few words about the relations of the large intestine. The *cæcum* is the blind commencement of the large intestine, and lies in the right iliac fossa; it is usually covered anteriorly and at the sides by peritoneum. The ileum joins it on its inner aspect, about two and a half inches above its blind end, and at this point the ascending colon begins. The *ascending colon* passes straight upwards through the right lumbar region. The *transverse colon* begins in the right hypochondrium, passes downwards into the umbilical region, and then ascends into the left hypochondrium; the central part is almost transverse, and crosses the abdomen, so that its lower edge (the convexity of the arch) is almost on a level with the umbilicus (Fig. 57, T.C.). On the right side it is continuous with the *hepatic flexure*, and on the left with the *splenic* flexure. The *descending colon* lies in the left lumbar region, and is attached by loose areolar tissue

to the outer border of the left kidney, and then to the fascia covering the quadratus lumborum—at first lying to the outer edge of that muscle; but as it passes downwards it inclines inwards, and lies more to the front of the muscle. It is only covered at the front and at the sides by peritoneum. The *sigmoid flexure* lies in the left iliac fossa, and is continuous above with the descending colon, and at the left sacro-iliac articulation becomes continuous with the rectum.

In Lumbar colotomy, or Amussat's operation, the descending colon is opened in the left lumbar region. The colon lies, according to ALLINGHAM, half an inch behind a point midway between the anterior and the posterior superior iliac spines. Mr C. HEATH simply takes the midpoint between the two spines. At the seat of the operation the gut lies in the angle between the psoas and the quadratus lumborum (Fig. 60). The descending colon (left) is chosen because (1) it is nearer the anus, (2) it is more fixed than the right colon, (3) it has a larger non-peritoneal surface, and (4) a meso-colon is more frequently found on the right side. In a *child* the danger of wounding the peritoneum would be much greater, because a descending meso-colon is often present.

The **patient** is placed on the right side somewhat, and the loin of the side to be operated upon made prominent by placing a pillow beneath the opposite side. The **instruments required** are the same as for gastrostomy, except that we will require some special apparatus for inflating the gut if it is empty—such as Lund's apparatus—and some tube and evacuator for emptying it if it be full, and if the operation is to be done in one stage. The **Surgeon** stands behind the

patient, and with a tape measures the distance between the anterior and the posterior superior iliac spines and makes a mark at the mid-point, or half an inch behind it, and draws a line from this vertically upwards to the costal margin—usually near the tip of the last rib. Various forms of **incision** may be used; the **oblique** is one very frequently adopted (Fig. 61, 2). It is four or five inches in length, and is made parallel with the intercostal nerves and the last rib, and midway between that bone and the iliac crest; its centre is placed opposite the ink line made in the ilio-costal space. (1) The skin and superficial fascia are divided, with fatty tissue cutaneous vessels and nerves. (2) The deep fascia is next divided, and then parts of (3) the latissimus dorsi, at the posterior end of the incision, and (4) the external oblique at the anterior part, are exposed and divided; these muscles, as well as those that follow, must be divided to the full extent of the superficial wound. Next (5) the internal oblique is divided in the same manner, and probably a small piece of (6) the serratus posticus inferior muscle. In the wound part of the transversalis muscle, with its undivided aponeurosis, and the posterior lamella of the fascia lumborum is exposed; further, at this stage we will find the last dorsal nerve and artery. They run outwards in front of the quadratus lumborum along the lower border of the last rib, and at the outer border of that muscle pierce the undivided aponeurosis of the transversalis muscle and pass forwards between it and the internal oblique. Open (7) this aponeurosis in the same way as the sheaths of arteries are opened, and enlarge the incision upon a director; in so doing it will probably be found that the compartment containing

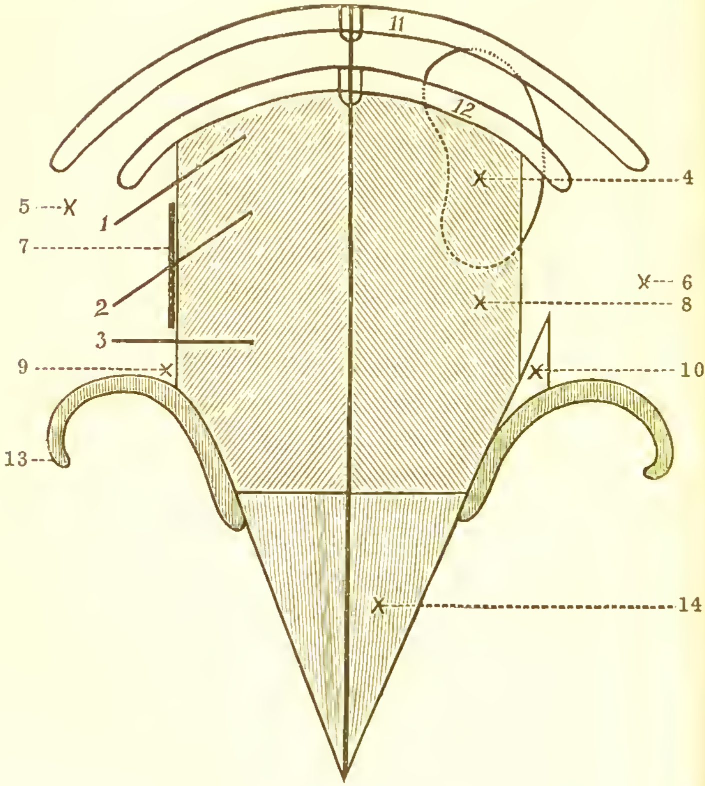
the quadratus lumborum is opened up as well as the undivided aponeurosis, and if the muscle it contains is in the way its edge may be freely notched. This care is necessary in opening this layer lest by the too free use of the knife the peritoneum should be punctured. The edges of the incision are now to be held aside with broad copper spatulæ, and the fatty tissue often found teased aside, when (8) the fascia transversalis is exposed and must be carefully torn through with the fingers, or blunt director, at the posterior angle of the incision as it lies in front of the quadratus lumborum muscle. The extra-peritoneal fat against which the colon rests and in which the kidney is embedded, at the upper part of the wound is then displaced by the finger, which is passed in at the wound to hook the colon forward. The gut may be recognised by its relation to the kidney, which can easily be felt at the upper part of the wound, the gut passing downwards off its anterior surface. In cases where there is great difficulty in finding the gut the patient may be turned on his back, when the gut will probably fall against the finger, or the gut may be inflated with air by the plan introduced by Lund, or by carbonic acid gas generated by introducing solutions of bicarbonate of sodium, and tartaric acid, separately, into the rectum. The remaining steps of the operation will vary according to the nature of the case. In all cases, where possible, the operation should be done in two stages just as gastrostomy; if this is not possible from the nature of the case, the *non-peritoneal* surface of the gut is brought to the wound, and a large curved needle with a stout silk ligature is passed, at the upper and lower parts of the wound, through the skin, then

across the bowel, and then through the skin at the opposite side. The threads are then to be given to two assistants, who thus hold the bowel steady and pulled well forward into the wound. The gut is then opened by a longitudinal incision between the two threads, and the finger is next passed into the bowel and the loops drawn out and divided, and the four ligatures thus formed tied. The extremities of the wound are then to be partially closed, and every means taken by additional stitches to prevent the escape of fæcal matters into the cellular tissue. The opening thus made in the colon is close to its junction with the splenic flexure. On the right side the steps of the operation are exactly alike. To avoid the inconvenience experienced by the accumulation of fæcal matters between the opening in the colon and the seat of the obstruction, MADELUNG cuts the bowel entirely across and stitches the upper end of the divided gut to the edges of the abdominal wound. He then empties the lower segment, washes it out, stitches up its divided end, and drops it into the wound and closes the skin incision over it. This lessens the irritation of the cancerous surface by the presence of fæcal matters, and probably also will lessen the tendency to prolapse of the mucous membrane of the gut. He originally proposed this method for cancer of the rectum and sigmoid flexure.

In the transverse form the incision (Fig. 61, 3) is made two finger-breadths above and parallel with the middle third of the crest of the left ilium, making the middle of the incision over the colon. By this incision the structures divided are practically the same as those cut in the oblique form.

The vertical incision (Fig. 61, 7) is made along the outer edge of the erector spinæ, between the last rib

Fig. 61.



POSTERIOR ABDOMINAL WALL, FROM BEHIND.

1. Incision for operations on the kidney. 2. Oblique incision for colotomy. 3. Transverse incision for colotomy. 4. Right kidney. 5. Point at which to tap the left kidney. 6. Point at which to tap the right kidney. 7. Vertical incision for colotomy. 8. Erector spinæ. 9. Point at which to open a psoas abscess posteriorly. 10. Triangle of Petit. 11, 12. Last two ribs. 13. Iliac crest. 14. Sacrum.

and the iliac crest, and in this case the structures divided are—(1) the integumentary coverings; (2) the

posterior layer of the fascia lumborum—and in doing so the compartment containing the erector spinæ is opened into, and this muscle is then drawn inwards; and (3) the middle layer is next divided, and with its division the compartment containing the quadratus lumborum is opened, and this muscle in turn is drawn well inwards; (4) the anterior layer of the fascia lumborum; (5) the fascia transversalis; (6) the loose areolar tissue and fat in which the gut is embedded. The gut may be recognised at the bottom of the wound by its greenish and distended appearance. In performing this operation it is necessary to avoid—(1) wounding the peritoneum; (2) allowing the contents of the gut being effused into the areolar tissue of the wound—and for this purpose, in cases where the gut must be opened at once, a wide india-rubber tube should be introduced into the opening, to allow the contents to escape gradually through it. After this, the sides of the opening in the gut are stitched to the sides of the incision, as described under the first form of incision. This operation may be rendered necessary on account of—(1) malignant stricture of the rectum with tenesmus, such as from cancer; (2) other strictures, such as from pressure of a tumour; (3) imperforate anus. By performing this operation in the same way on the opposite side, the caput cæcum, or ascending colon may be reached.

Littré's Operation or Inguinal Colotomy.—In this operation the colon is reached in the iliac region by opening into the peritoneal cavity and into the gut through its peritoneum covered surface. The **incision** resembles that for ligature of the external iliac artery. Littré operated on the left side; the incision is carried

from a little above the level of the anterior superior iliac spine downwards and inwards about half an inch above and nearly parallel with Poupart's ligament, for two and a half or three inches. The incision must be external to the deep epigastric artery, and above the level of the deep circumflex iliac.

The **structures divided** are—(1) the skin and superficial fascia, fatty tissue and deep fascia, with the cutaneous nerves and the superficial external circumflex vessels; (2) the external oblique; (3) the internal oblique; (4) the transversalis muscle, with branches of the deep circumflex iliac artery; (5) transversalis fascia and extra-peritoneal fat, and (6) the peritoneum. The operation should be done, if possible, in two stages, as gastrostomy. The large gut is distinguished from the small by the longitudinal muscular bands, and by the appendices epiplöicæ. LITTRÉ'S operation in the **left** groin was originally proposed for cases of congenital absence, or deficiency of the rectum; in children, however, it is well to bear in mind that the sigmoid flexure is often misplaced, and may be on the right side or in the pelvis. It is also used in cases of stricture of the rectum and *lower* part of the sigmoid flexure. The operation is said to be less severe, and it places the anus in a more convenient situation, so that the patient can attend to it himself; for this reason it should also be preferred in the labouring poor, who are unable to afford a special attendant to attend to and keep the parts clean, when it is placed behind. Statistics seem to show that it is slightly more fatal than AMUSSAT'S operation. Malignant stricture is very frequently situated in the sigmoid flexure, and in this case AMUSSAT'S operation must be performed.

LITTRÉ'S operation may also be performed on the right side, in this case opening the cæcum; this side is also to be preferred in cases of long standing intestinal obstruction. This subject is ably discussed by Mr F. TREEVES, in his work on '*Intestinal Obstruction.*'

LAPAROTOMY.

This may be defined as making an opening into the abdomen, either for the purposes of diagnosis (exploratory) or treatment, or both. It is used in cases of acute strangulation of the gut of all kinds and from all causes, such as constricting bands, cords, diverticula, strangulation through slits and apertures, &c. It is also used in treating all kinds of internal hernia, and of reduction *en masse* after external hernia; also for volvulus and intussusception. The incision is the same as in ovariotomy; it is used as a preliminary operation in cases where enterotomy, enterectomy, &c., is to be performed. I will not describe the operation in detail, but merely indicate the more important points; the whole operation must be conducted on the same principles and with the same care as ovariotomy. The patient is placed on a high table, with his legs hanging over the end of it, and an incision, sufficiently large to admit the hand, is made between the pubes and the umbilicus through the *linea alba:* by making the incision in the linea alba no vessel of any size is divided, no intermuscular cellular planes are opened up, the wound is not deep, and its edges can afterwards be readily approximated without any tendency afterwards to hernial protrusion of the bowel. The instruments required are the same as in gastrostomy, and the instrument clerk should have all the instruments,

especially the sponges and Wells's forceps carefully counted and noted, so that he may call the roll before the wound is stitched up, lest any of them be left in the abdominal cavity. The temperature of the room must be carefully regulated and the bladder emptied before the operation, lest it be cut into. When the outer surface of the peritoneum is exposed all bleeding vessels must be secured before it is opened; it should be opened like the sheath of an artery, and the opening enlarged with a probe-pointed bistoury, guided by the forefinger of the left hand; and after it is opened care must be taken to prevent protrusion of the intestines. At the completion of the operation the 'peritoneal toilet' must be performed with the greatest care and completeness. In closing the wound the deep sutures of carbolized silk must include the peritoneum, so that the divided sides of that membrane shall be brought into close contact and unite by the first intention.

ENTEROTOMY.

Nélaton's Operation for Intestinal Obstruction—Enterotomy.—The abdomen is opened in the iliac region, preference being given to the right side, by an incision the same as that used in Littré's operation—parallel with and a little above Poupart's ligament and external to the deep epigastric artery. The first *distended* coil of bowel that presents itself is then drawn into the wound; on the right side it is almost always the lower end of the ileum that presents. The operation is completed in one or two stages, according to the nature of the case; if possible it should be done in two stages in the manner already explained under '*gastrostomy*.' Mr Treeves objects to *primary* enterotomy on

the following grounds — (*a*) it is only a palliative measure at the best; (*b*) it is not founded upon sound surgical principles; (*c*) it is carried out more or less independently of diagnosis: (*d*) it is done in the dark and leaves the *cause* of the disorder untouched. It may often, however, be performed with advantage as a *secondary* operation, *e.g.*, after lumbar colotomy where the colon is exposed below the obstruction; also, sometimes after an exploratory laparotomy, it may be found that nothing else can be done. In favour of the operation *(primary)* is its low mortality, ease of performance, and the almost absolute certainty of making an opening in the gut *somewhere* above the obstruction.

RESECTION OF THE INTESTINE.

In this operation a diseased portion of varying size is cut away and removed from the body. It may be performed for stricture, simple and cancerous, occlusion of the gut by hopeless matting, and for gangrene. It is called **Enterectomy** when performed on the small intestine; **colectomy** when performed on the large. In many cases it is the only operation which *cures* the disease and therefore possesses this great advantage over *enterotomy*; and it further does away with the necessity for a permanent artificial anus. As regards the amount that *may* be removed, it is difficult to state definitely, but a couple of yards have been removed without any apparent damage to the intestinal tract, so far as function was concerned. There are two modes of performing the operation—(1) The part of the gut is removed, the two divided ends are reunited, thus restoring the lumen of the tube; the gut is then put back into the abdomen, and the external wound

closed. The objections to this plan are—(*a*) Although the obstructing part is removed, yet the distension of the gut above remains for some time after the operation, as the segment of the bowel involved in the operation is paralysed for a time, and prevents a free passage along the tube. (*b*) The operation is very difficult, long, and tedious, and this is bad for the patient, who probably before the operation was already in a low condition; (*c*) it may be impossible to suture the gangrenous bowel, or the suture line may slough and lead to extravasation and death. For these reasons the next method should always be preferred, viz., (2) instead of stitching the divided ends together, an artificial anus is formed by the ends of the divided gut being stitched to the skin incision, first the distal and then the proximal. At a later period another operation is performed for the cure of the artificial anus; a median laparotomy is first performed and the diseased segment of the gut is pulled out at the wound; the wound is then plugged with clean flat sponges to prevent the entrance of fæces into the abdomen from the segment to be excised, and also to prevent the protrusion of more bowel. The bowel must now be occluded on each side of the part to be excised by some form of clamp; the one invented and used by Mr Treeves has its compressing surfaces covered with india-rubber, and it is so made that the two ends can slide along iron rods so as to approximate the ends of the divided gut before the introduction of the sutures. The necessary amount of gut is then removed with the scissors, and a V-shaped piece of the mesentery removed, and all bleeding vessels ligatured. The two parts of the clamp are next approximated and two rows of

sutures introduced—the inner to bring the edges of the mucous membrane together (Czerny), and an outer row to unite the serous surfaces (Lembert). Gussenbauer brings both the mucous and serous layers into contact by a single suture. When the gut is divided the longitudinal muscular fibres retract and carry the serous covering with them so that the mucous coat can be readily reached and sutured. Various plans have been tried in order to make the gut rigid during the introduction of the sutures, such as plugs of gelatine or dough, decalcified bone, a sausage-shaped india-rubber bag that can be inflated, &c. According to Mr Treeves, about fifteen sutures are required for the inner row, and twenty-five for the outer. The clamps are now removed, the gut dropped into the abdomen, and the abdominal wound closed.

In the **second method**, when the diseased part is removed, the clamp is removed from the distal end of the gut and its margin stitched to the skin incision; the proximal end is then treated in the same way, taking care not to allow its contents to escape into the peritoneal cavity. After a time the cavity of the gut is rendered continuous by a second operation. This method is much better, more easily performed, and safer than the other.

THE LIVER.

This organ fills up the greater part of the right hypochondriac region, extends through the epigastric and passes slightly into the left hypochondrium. The lower border, at the left side, is close to the apex beat, in the epigastric region it is midway between the ensiform cartilage and the umbilicus, and on the right

side it follows the costal margin. Being attached to the diaphragm it is depressed during inspiration and rises during expiration; at the end of expiration its upper border corresponds to the fourth intercostal space or upper border of the fifth rib. At the lower part the liver lies in contact with the chest wall, but higher up a layer of lung tissue, and the diaphragm intervene, as well as the pleural and peritoneal cavities. A penetrating wound, therefore, of the chest wall, say about the fifth, sixth, or seventh intercostal spaces would go through both liver and lung, and open up both the pleural and peritoneal cavities. The '*upper*' surface of the liver is in contact with the diaphragm; the *under* surface is in relation to the stomach on the left side, and on the right side with the gall bladder, the duodenum, the hepatic flexure of the colon, the right kidney and suprarenal capsule. The **gall bladder** lies in a depression on the under surface of the liver; its fundus is directed towards the abdominal wall, being directed downwards and forwards and to the right, and projects slightly beyond the anterior edge of the liver. It is situated behind the ninth costal cartilage, close to the right linea semi-lunaris (Fig. 58, *g.*). In cases where the common bile duct is obstructed, as by gall stones, the gall bladder is distended with bile, often forming a large tumour. To relieve this condition the gall bladder has been opened, by LAWSON TAIT, and others, and the obstruction removed; this operation is known as **cholecystotomy** The incision is made over the most prominent part of the tumour parallel with the linea alba, or the incision may be made in the linea alba or in the linea semi-lunaris. The operation may be done in one or two

stages as in gastrostomy. Care must be taken in dislodging the stones lest perforation take place. Tumours connected with the liver necessarily partake of the respiratory movements, and in this way may be distinguished from tumours of the right kidney.

CHAPTER XXXV.

THE ABDOMEN *(Continued).*

The Spleen.—The spleen lies far back in the left hypochondrium behind the stomach. It is not placed vertically, as is often described, but lies very obliquely; 'it is oblique in two directions, viz., from above, downwards, and outwards, and from above downwards, and forwards' (CUNNINGHAM). It lies parallel with and follows the obliquity of the ninth, tenth, and eleventh ribs; its 'upper' extremity, therefore, points towards, and is not very far removed from, the spinal column. The *upper* end is attached to the diaphragm by the phrenico-splenic ligament; by this means, therefore, the organ partakes of the respiratory movements of that muscle, sinking during inspiration and rising during expiration. This is one valuable means of diagnosing splenic tumours. Its *lower* end rests on the phrenico-colic ligament which, coupled with the natural obliquity of the organ, guides the enlarged spleen in a direction downwards and forwards towards the umbilicus. The *outer* surface rests against the diaphragm, which lies between it and the ribs before mentioned; between this surface, therefore, and the skin, we find the peritoneum, diaphragm, pleura covering the upper surface of the diaphragm, a wedge-shaped mass of lung tissue encased by pleura, the

pleural 'cavity,' the ninth, tenth, and eleventh ribs covered with pleura on their inner surfaces, and lastly the soft parts of the chest wall. It will be evident, therefore, that the spleen cannot be excised from its external aspect. The inner surface is concave, and is connected with the stomach by the gastro-splenic omentum — the structure which causes the most anxiety during excision of the organ. The *anterior border* is usually notched; this fact is useful in diagnosing enlargements of the spleen from other tumours. The lower, or outer, end of the spleen in health usually reaches midway between the posterior and mid-axillary lines, over the ribs already named. At this point it most nearly reaches the surface, and a small portion may be made out of percussion; as it passes upwards and backwards, however, from this point, it is separated, as already mentioned, from the surface, by the left lung, and the thick layer of muscles of the back, and is beyond the reach of percussion. The splenic dulness is more evident when the patient lies on his right side, for then the spleen gravitates forwards; the normal spleen is best percussed when the patient is standing with the left arm removed from the side. In consequence, however, of the near presence of the stomach and the splenic flexure of the colon, it is necessary to percuss very lightly, in order to obtain its true position.

Splenic tumours and enlargements are to be distinguished by—(1) They move with the diaphragm during inspiration and expiration; (2) the position shifts by turning the patient over to the right side, when it gravitates forwards; (3) the mode of origin and course —they begin above in the left hypocondrium, and

grow downwards and forwards towards the umbilicus, curving round in front of the fundus of the stomach and colon; (4) the dullness is continuous with that of the normal splenic dulness; (5) they are usually painless; (6) the tumour has a *notch* in the anterior border; (7) by passing one hand into the ilio-costal space, while the other rests flat on the front of the abdominal wall, it may be possible to tilt up the tumour against the hand; (8) there is a line of resonance between the tumour and the vertebral spines, and the fingers can be readily dipped between the tumour and the spinal groove.

Excision of the Spleen.—This operation has been performed for (1) wounds or injuries of the spleen; (2) floating spleen; (3) simple hypertrophy; and (4) malarial spleen. It must *not* be performed for the enlarged spleen of leucocythæmia; in sixteen cases where it was performed for this condition *every* patient died. As regards the **incision**—it may be either made from the eighth costal cartilage along the left linea semilunaris to the required extent (Fig. 58, 2), or in the linea alba with its centre opposite the umbilicus. The details of the operation closely resemble those of ovariotomy, the spleen being isolated from its surroundings, and its pedicle secured by ligature; as already pointed out, the gastro-splenic omentum, attached to the sides of the hilus, and containing the large vessels, forms the most difficult part of the operation. The special **dangers** of the operation are— (1) hæmorrhage from the omental vessels; (2) injury to the pancreas; (3) injury to the dense plexus of sympathetic nerves in this region in relation with the left supra-renal capsule; it is probably from this cause that persistent vomiting sometimes follows the operation.

THE KIDNEYS.

The **Kidneys** are situated in the right and left lumbar regions, opposite three and a-half vertebræ—from the last dorsal vertebra to the middle of the third lumbar vertebra; the *hilus* of the kidney is opposite the first lumbar vertebra. They lie entirely *behind* the peritoneum, embedded in loose areolar tissue, and are placed somewhat obliquely, the upper ends of the kidneys inclining towards the vertebræ. **Relations.**—Each kidney rests on the corresponding crus of the diaphragm, quadratus lumborum, and psoas,—or, rather, on the fascia covering these muscles. In *front* is the colon; at the *upper* end is the supra-renal capsule; the *lower* end is a little above the crest of the ilium. The above relations are common to the two kidneys; but there are certain special relations—in front of the right kidney is the second part of the duodenum; in front of the left, the pancreas; at the upper end of the right kidney is the right lobe of the liver; at the upper end of the left, the spleen. The right kidney is a little lower than the left, probably because the liver presses it down somewhat—the left kidney reaches to the upper border of the eleventh rib, but the right only reaches to the middle of the corresponding rib on the opposite side. The *ureters* arise at the hilus of the kidney, from the dilated pelvis, and also pass down behind the peritoneum, and at the upper part of their course rest on the psoas muscle.

Relation of the Kidneys to the Surface of the Body.—**Anteriorly** (Fig. 57).—According to Mr MORRIS their position may be defined thus—(1) A horizontal line through the umbilicus is below the lower edge of each

kidney, but the left is a little higher up than the right; (2) a vertical line carried up from the middle of Poupart's ligament, parallel with the middle line of the body, has one-third of the kidney to its outer side, and two-thirds to its inner side. **Posteriorly** (Fig. 61).—(1) A line parallel with, and one inch from the spinous processes of the vertebræ, extending from the lower edge of the eleventh dorsal spine to the corresponding part of the third lumbar vertebra. (2) A line parallel with the first, and of the same length, but two inches and three quarters to its outer side will mark the outer border of the kidney. By joining the upper and lower ends of these lines a little box is marked out which corresponds to the position of the kidney.

In carrying the **dissection** through this box the following structures are found covering the kidney:—(1) Skin with the cutaneous branches of the lower dorsal and lumbar nerves, and cutaneous twigs of the intercostal and lumbar arteries; (2) deep fascia; (3) aponeurosis, and part of the muscular fibres of the latissimus dorsi; (4) serratus posticus inferior; (5) posterior layer of the aponeurosis of the transversalis; (6) the internal oblique; the external oblique muscle is also seen, as well as the last rib, and the lowest external intercostal muscle; (7) the erector spinæ muscle; (8) then the middle layer of the aponeurosis of the transversalis muscle. The quadratus lumborum muscle is now exposed, and resting on its anterior surface are the anterior branches of the four lumbar arteries. (9) The quadratus and vessels are now removed, and after that (10) the anterior layer of the aponeurosis of the transversalis; (11) a quantity of loose adipose tissue is next to be removed, when the posterior surface of the kidney

is exposed. Crossing the posterior surface of the kidney from above downward we find (*a*) the anterior branches of the last dorsal vessels and nerve; (*b*) ilio-hypogastric nerve; (*c*) the ilio-inguinal nerve; to the inner side of the kidney is the psoas.

Tumours of the kidney (1) usually first show themselves a little above and external to the umbilicus, filling up the hollow in the loin; (2) the resonant large intestine passes in front of the tumour; (3) they do not partake of the respiratory movements; (4) there is no resonant line between the tumour and the spine; (5) it has no sharp notched edge like the spleen, but is rounded on every side.

OPERATIONS PERFORMED ON THE KIDNEY.

Tapping the Kidney.—This operation is performed for (*a*) Hydronephrosis, (*b*) pyonephrosis, (*c*) large isolated cysts, whether serous, bloody or from hydatids, when there is danger of the cyst wall giving way, or the pressure symptoms are serious. **Seat of Puncture.**—Over a fluctuating point if there is one; if not, then on the **left side** about an inch in front of the last intercostal space (Fig. 61, 5): on the **right side** midway between the last rib and the iliac crest about two inches and a half behind the anterior superior iliac spine (Fig. 61, 6). The puncture is made in this position on the right side, to avoid the liver. **Risks of the operation.**—(*a*) Effusion of the contents into the peritoneal cavity; the peritoneum is usually adherent and prevents this accident; (*b*) puncture of gut; (*c*) puncture of some of the large abdominal vessels; (*d*) puncture of the liver; (*e*) puncture of the pleura if too near the last rib.

Nephrotomy.—By this is meant an incision into the kidney for purposes other than the removal of a calculus. It is used (*a*) for hydronephrosis when the cyst refills quickly after repeated tappings. In cases of this nature, Dr Duncan recommends the injection of iodine into the cyst after evacuation of its contents before resorting to nephrotomy; the only disadvantage of this plan is the severe pain to which it gives rise. (*b*) in cases of hydatid cysts where it is impossible to empty the cyst thoroughly; (*c*) pyonephrosis; (*d*) for calculus, or tubercular abscess. The **incision** resembles that for lumbar colotomy, only being a little nearer the median line and higher up (Fig. 61, 1). The one Mr Morris recommends is slightly oblique, in the ilio-costal space, beginning over the outer edge of the erector spinæ and continued forwards for three inches and a half. The kidney is then exposed, the cyst opened and the contents evacuated, the edges stitched to the sides of the incision, and a drainage tube inserted—the intention being to make the wound heal from the bottom upwards.

Nephro-Lithotomy.—This operation was first performed by Mr Henry Morris in the year 1880. It is an incision into the secreting tissue, or the pelvis of the kidney, for the express purpose of removing a calculus. The cases in which he recommends this operation are, when the symptoms of renal calculus are not influenced by medicinal treatment and interfere with the comfort and usefulness of the patient's life. Where there is almost constant pain in one loin, passing along the ureter probably to the testicle of the same side; where there are recurring attacks of renal colic with blood, pus, or albumen in the urine, probably with the passage

of gravel per urethram. An **incision** four inches and a half long is made parallel with the last rib, and three-quarters of an inch below it (Fig. 61, 1). When the kidney is exposed then feel its posterior surface with the finger for the presence of hardness or irregularity, and if this fail to detect a stone then pass a fine needle into the secreting substance. In removing a stone it is better to cut into the secreting substance as there is less risk of urinary fistula than when the incision is made into the pelvis. A drainage tube is then introduced and the wound stitched up, dressings applied, and a pad of German peat moss placed below to absorb the urine. The **dangers** are hæmorrhage from the divided renal substance, cellulitis, renal abscess, renal fistula, and lumbar hernia.

Nephrorraphy.—This operation consists in cutting down upon and exposing the kidney, and stitching it to the edges of the wound. It is employed for floating, moveable, or wandering kidney, which is the seat of frequent severe and spasmodic attacks of pain, or continuous suffering. An **incision** is used similar to that for nephrotomy.

Nephrectomy—Is the complete removal of a kidney from the living body. It is used for the removal of a diseased kidney in which all less radical measures have failed; in some cases where nephrolithotomy is not practicable; in ureteral urinary fistula; in badly wounded or ruptured kidney; tumours, *small and medium sized*, of various kinds, and sometimes in moveable kidney. It was first performed by Simon of Heidelberg, who laid down the law that it is only to be done when the patient's life is in danger and all other means have failed. It may be performed through a

lumbar incision; the advantages of this form of incision are (1) the peritoneum is not opened; (2) the wound drains well. An **incision** is made four and a half inches in length, slightly oblique, at least half an inch below the last rib, lest the pleura be wounded (Fig. 61, 1), except that it is on a higher level the incision resembles that for colotomy. When the kidney is reached a second incision is made by dividing the tissues from within outwards by a probe-pointed bistoury; this second cut is vertical and joins the previous incision about an inch from its posterior end. By means of the second incision the pedicle is ligatured more easily; in cases where the space is small, some Surgeons advise excision the last rib, although Mr MORRIS strongly condems this practice. In the pedicle the vessels and the ureter are usually ligatured separately; the ligature is passed by means of an aneurism needle. If the vessels are ligatured separately the *artery* must be ligatured before the vein. The lower ribs are then pulled upwards and the kidney dragged into the wound, another ligature applied to the pedicle which is then divided and the kidney removed; in many cases it will be advisable to incise the capsule and enucleate the kidney, leaving the capsule behind with the pedicle — especially in cases where there has been much perirenal inflammation. All bleeding vessels are then tied, the sutures cut off short and dropped into the wound; a tube, like that used in lithotomy, is then inserted and the wound closed. The **dangers** of this operation are—tearing open the peritoneum or colon, injury to the vessels from too great strain, giving rise to hæmorrhage later, uræmia, hæmorrhage from the broken up kidney-substance, and shock.

The **Abdominal Incision**; this form is used in the case of large tumours and for the excision of wandering kidney. An **incision** is made opposite the kidney to be removed in the corresponding linea semi-lunaris, its length varying with the size of the tumour to be removed. This incision is the more fatal of the two, and for this reason the other is to be used where possible. Its chief **dangers** are—septic peritonitis, pulmonary embolism, and pyæmia. An advantage of the abdominal method is that both kidneys can be examined, especially if the incision be made in the linea alba, so that there is less risk of removing the healthy kidney and leaving the diseased one. Of course a median laparotomy might be performed, the kidneys examined, and then the diseased one removed by the lumbar operation.

PARACENTESIS ABDOMINIS.

A small incision is made with a scalpel in the middle line, a little below the umbilicus (about two inches), and through this opening the trocar is thrust. It is better, however, to keep up pressure on the abdomen as the fluid escapes, lest the abdominal vessels burst on account of being thus suddenly relieved from the pressure of the fluid. The **instruments required** are—scalpel, trocar or aspirator, split sheet, sponges, needle and silk sutures, scissors, wool and collodion, bucket, adhesive plaster, brandy, &c. Pressure is best kept up by means of a broad flannel roller, split at each end to within six inches of the middle, and applied in such a way that the untorn part covers the front of the abdomen, while the ends are crossed behind and given to an assistant on each side to keep up the pressure as

the fluid escapes. The Surgeon must be ready to close the canula with his finger should the flow threaten to become intermittent, lest air be admitted. Another precaution is to make sure that the bladder is empty before the operation. In tapping the abdomen in other situations, the course of the epigastric vessels must be kept in mind. The possible dangers of the operation are hæmorrhage, wound of the bladder, wound of the bowel from not selecting a dull area, or from plunging the instrument too deeply.

CHAPTER XXXVI.

THE ABDOMEN *(Continued)*.

HERNIA.

By this term is meant a protrusion of a part of the viscera through some abnormal opening in the abdominal wall. A hernia consists of a *sac* (that is the prolongation of the peritoneum which overlies the hernia) and *contents*. Hernia is said to be *inguinal* when it comes through the opening or canal situated in the inguinal region of the groin; and *femoral* when it comes through the opening or canal situated in the femoral region of the groin.

A hernia is said to be **reducible** when *all* the contents can be pushed back into the abdominal cavity. It is called **irreducible** when all the contents cannot be returned; it may be wholly or partially irreducible.

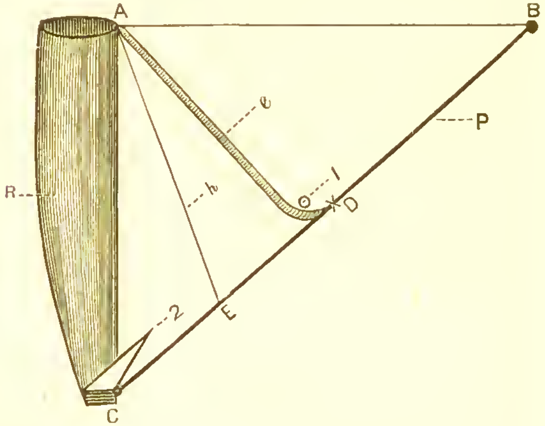
An **obstructed** hernia is where the *contents of the bowel* are checked in their passage at the seat of the hernia—a local constipation; the term **incarcerated hernia** is sometimes applied to the same condition occurring in an *irreducible* hernia. An **inflamed hernia** is one in which the peritoneal envelope is inflamed—a local peritonitis. A **strangulated hernia** is one where the venous blood return is checked by some constricting structure; this is followed by swelling, œdema and then the arterial supply is checked also, and unless relieved

the condition quickly passes on to gangrene of the bowel.

INGUINAL HERNIA.

This form is much more common in males, because in them the inguinal canal is larger, while the crural ring is smaller, than in females, on account of the less expanded iliac crests. The space concerned in inguinal

Fig. 62.



SPACE CONCERNED IN INGUINAL HERNIA, FROM THE INSIDE.

B. Anterior superior spine. C. Crest of pubes. D. Centre of Poupart's ligament. P. Poupart's ligament. R. Rectus abdominis. 1. Internal abdominal ring. 2. External abdominal 'ring.' *e.* Deep epigastric. *h.* Obliterated hypogastric. C. A. D. Hesselbach's triangle. C. A. E. Part covered by the 'conjoined tendon.' E. A. D. Part not covered by that tendon.

hernia is triangular, corresponding to the inguinal region of the groin, and has the following **boundaries**: —*Below*, by Poupart's ligament; *internally*, by the linea alba; and *above*, by a line drawn from the anterior superior iliac spine to the linea alba. In connection with the subject of hernia, it will be well to consider

the structure of the abdominal wall at this point; the two longitudinal muscles (the rectus and pyramidalis) may be left out of account for the time being. If we were to examine the triangular space, mentioned above, from the inside of the abdomen, we would find that it is subdivided into two triangular parts by the deep epigastric artery—the artery, in fact, almost bisecting the triangle in question—an outer triangular part, and an inner triangular part known as Hesselbach's triangle (Fig. 62, C. A. D.). In dissecting the abdominal wall in the region of the outer triangular part, we find—(1) skin; (2) superficial fascia; (3) tendon of the external oblique; (4) the internal oblique; (5) the transversalis muscle; (6) fascia transversalis; (7) extra-peritoneal fat; (8) peritoneum. In the inner triangular space (that is, Hesselbach's triangle) the structures met with with are similar, except that the tendons of the internal oblique and transversalis muscles are inseparably united, forming the 'conjoined tendon,' which is attached to the crest of the pubes and the pectineal line, and which, therefore, takes the place of the above muscles in this space. The conjoined tendon, however, does not entirely cover in the whole of Hesselbach's triangle; the obliterated hypogastric artery passes across the triangle in question, internal to and almost parallel with the deep epigastric artery, and the space between these two structures is not covered by the conjoined tendon. For this reason, we shall see later that there may be *two* forms of *direct inguinal hernia*.

The Inguinal Canal.—This is an oblique opening through the anterior abdominal wall, and is directed downwards and inwards, lying parallel with and a little above the inner half of Poupart's ligament. It com-

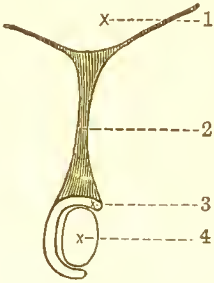
mences at the internal abdominal ring, and ends at the external ring, and is about an inch and a half to two inches in length. The *external* abdominal ring is oval or triangular in shape, directed upwards and outwards; the base is formed by the crest of the pubis, and the lateral boundaries are known as the *pillars* of the ring (Fig. 62, 2). The upper or *internal* pillar or column, consists of a flattened part of the tendon of the external oblique, passing downwards to be fixed to the front of the symphysis pubis; the lower or *external* pillar is chiefly formed by the inner end of Poupart's ligament, and is thicker and more rounded than the other pillar, and is attached to the spine of the pubes. At the upper part of the ring there are some fibres seen passing in a transverse direction, and these are called the *intercolumnar fibres.* Poupart's ligament is attached internally to the spine of the pubes, and also into the pectineal line, forming Gimbernat's ligament, and is to be regarded as part of the insertion of the external oblique; a part, however, of its tendon of insertion, springing from the pectineal line and pubic crest, passes behind the internal pillar of the ring, and decussates in the linea alba with the tendon of the opposite side, forming the 'triangular fascia.' The ring transmits the spermatic cord in the male and the round ligament in the female. The internal ring is an opening in the fascia transversalis, and is situated about half an inch above Poupart's ligament, at a point midway between the symphysis pubis and the anterior superior iliac spine (Fig. 62, 1). **Boundaries of the Canal.**—In *front*—(1) the external oblique (throughout its whole length); (2) the internal oblique (for its outer third); (3) the cremaster muscle. *Behind*—(1) Fascia transversalis

(throughout its whole length); (2) the conjoined tendon (for its inner third); (3) the triangular fascia; (4) the deep epigastric artery. The *floor* is formed by Poupart's ligament, and the *roof* by the free arched lower border of the transversalis muscle.

The Descent of the Testicles.—The testicles are originally situated in the abdominal cavity, below the kidneys and behind the peritoneum; but before birth they pass down into the scrotum. Up to about the end of the sixth month of fœtal life they are found below the kidney, at the posterior part of the abdominal wall; but as the process of development becomes more and more complete, they gradually descend, so that, by the seventh month, they are situated behind the internal abdominal ring. During the eighth month they pass through the canal, and by the end of the ninth month they have reached the bottom of the scrotum. The means by which this descent is effected is rather obscure, and was formerly believed to be due to the contraction of certain muscular bands—the 'gubernaculum testis'—which piloted the testicles into their proper haven, but is now commonly believed to be the result of a general process of development. A process of peritoneum—the *processus vaginalis*—passes down into the scrotum, and precedes the testicle by some time in its descent; and as the testicle originally lies behind the peritoneum, and still retains this position in its descent, both layers of this pouch of peritoneum necessarily lie in front of the testicle. But, as the testicle passes down it receives certain coverings from the layers of muscle and fascia forming the anterior abdominal wall: thus it receives (1) the *intercolumnar* or *external spermatic fascia* from the external

oblique, as it passes between the pillars of the ring; (2) the *cremasteric muscle* or *fascia*, continuous with the internal oblique; (3) the *infundibuliform* or funnel-shaped fascia, from the fascia transversalis (also called the *internal spermatic fascia*). The transversalis muscle gives no covering to it, as the free arched border of the muscle is too high, the testicle passing through below it. All these coverings are continued over the testicle as it lies in the scrotum. The pouch of peritoneum preceding the testicle at first communicates with the peritoneal

Fig. 63.



NORMAL CONDITION OF THE PROCESSUS VAGINALIS IN THE ADULT.

1. Peritoneal cavity. 2. Obliterated vaginal process. 3. Cavity of tunica vaginalis. 4. Testicle.

cavity; but a little time before birth its narrow neck becomes closed, while the unobliterated lower end forms the tunica vaginalis, which is in this way entirely shut off from the abdominal cavity (Fig. 63). We have described the descent of the testicle at this point, because one form of inguinal hernia takes exactly the same course, and receives similar coverings.

DIRECT AND OBLIQUE INGUINAL HERNIA.

The Oblique.—This form is named oblique from the direction it takes—passing through the oblique inguinal

canal; it is also called *external* from its relation to the deep epigastric artery, which lies to its inner side. It takes the same course as the testicle did—that is, it enters at the internal abdominal ring, passes through the whole length of the canal, and escapes by the external ring into the scrotum; it passes through that part of the triangular space concerned in inguinal hernia that lies to the outer side of the epigastric artery, and whose structure has already been described (Fig. 62). The hernia usually passes down in front of the cord, between the cord and its coverings; its neck lies above Poupart's ligament and internal to the spine of the pubes. The *coverings* of this form of hernia are —(1) Skin; (2) superficial fascia; (3) intercolumnar fascia; (4) cremasteric fascia or muscle; (5) the infundibuliform fascia; (6) subperitoneal fat; (7) the peritoneal sac. The 'FASCIA PROPRIA' of the hernia is the united subperitoneal fat and the fascia transversalis. The sac, as here seen from the outside, may be recognised by its *rough* and *bluish* appearance.

Direct Hernia.—It is called direct from the direction it takes; it is also called internal, from its relation to the deep epigastric artery, which lies to its outer side. This form does not pass through the whole length of the inguinal canal, but escapes from the abdomen through that part of the triangular space concerned in inguinal hernia, known as Hesselbach's triangle (the boundaries of which, and a description of the structures forming the abdominal wall at that point, have already been described, Fig. 62), enters the inguinal canal, pushing the conjoined tendon before it (unless, as is sometimes the case, the conjoined tendon is small, and does not fill up all the triangle in question), passes

through the lower part of the canal, and escapes by the external abdominal ring. The *coverings* in this form of hernia are almost the same as in the oblique form; the only difference being that, instead of reading 'cremasteric fascia or muscle,' as in the oblique variety, read 'conjoined tendon.' This tendon, as we have said, is the tendon of the conjoined internal oblique and the transversalis muscles; but, as the transversalis gives no covering to any form of inguinal hernia, it may simply be read in place of the cremasteric muscle, which is continuous with the internal oblique: in other respects the coverings of the two forms are exactly the same. But as already indicated there are **two forms of direct hernia.** The obliterated hypogastric artery passes across Hesselbach's triangle dividing it into two parts (Fig. 62, *h.*). (*a*) In the **most common** form of direct hernia the gut leaves the abdomen *internal* to the obliterated hypogastric artery, and therefore passes through the conjoined tendon. (*b*) In the **second** the hernia passes between the obliterated hypogastric artery and the deep epigastric (Fig. 62)—altogether external to the former structure, and therefore has no covering from the conjoined tendon, the coverings in this case being practically the same as in the ordinary oblique form. On the inner surface of the abdominal wall in this situation certain ridges are found—in the middle line is the *urachus*, and then on each side of this we find ridges formed by the obliterated hypogastric and the deep epigastric artery. By means of these ridges little peritoneal fossæ are formed—one external to the deep epigastric artery, another between that vessel and the obliterated hypogastric, and a third internal to this latter structure. These fossæ indicate a *local weakness*

in the abdominal wall, and this, combined with some exciting cause, explains the frequency of hernia in these situations. Were the walls of the abdominal cavity equally strong in all situations there could be no reason why it should occur in one situation more than in another. In practice, it is extremely difficult, and often impossible, to distinguish between the oblique and the direct forms; because in the oblique form the internal abdominal ring is apt to be drawn towards the middle line, more especially if the hernia be of long standing. The diagnosis would not be important were it not from the different relations of the two forms to the deep epigastric artery—the oblique being external and the direct internal to that vessel; and this might have an influence in determining the direction of the incision in the operation for strangulated hernia, it being necessary to cut from the artery—or, at least, not to cut towards it. But, from the difficulty in diagnosis above indicated, the best rule is, in *every* case, to cut upwards and slightly inwards parallel to the deep epigastric artery; and by this means the artery escapes injury. The vessel in the normal condition, as we have already stated, almost bisects the triangular space concerned in inguinal hernia—passing from near the middle of the base (Poupart's ligament) to its apex, which is formed by the meeting of the horizontal line with the linea alba (Fig. 62). The **seat of strangulation** may either be—(1) In the neck of the sac becoming thickened and constricted by plastic deposit, and its subsequent organisation and contraction; this is the most common cause; (2) by the intercolumnar fascia; or (3) by the transversalis fascia; (4) ravelling of the contents among

each other, *e.g.*, a kink of bowel through a hole in the omentum.

STRANGULATION.

Operation for Strangulated Inguinal Hernia.—The object of this operation, as in all cases of a similar nature, are—(1) To divide the constricting structure, and (2) to perform the radical cure at the same time—tie the neck of the sac, and mat the rest of it together by several catgut sutures, or else cut it off altogether, and then bring the walls of the canal together either by wire or catgut sutures, or both, leaving enough room below the lowest suture for the passage of the spermatic cord. There are two forms of operation—(*a*) The **extra-peritoneal**, where the sac of the hernia is not opened, the constricting cause being divided outside the neck, and the bowel afterwards reduced; this form, as a rule, is to be avoided, for the usual constricting cause is the thickened and contracted neck of the sac itself, and besides the contents might be ravelled amongst each other, or the bowel gangrenous. (*b*) The **peritoneal** method where the sac is opened; this is the best method, and no bad results are likely to follow the opening of the sac with the present improved methods of operating and treating wounds, and, further, the true condition of the hernia can be thus readily *seen*, and the contents examined. In the former method a feeling of doubt and insecurity must always exist as to the condition of the hernia.

Instruments.—Sharp scalpel, a probe pointed bistoury, dissecting forceps, directors straight and curved, Spence's hernia director, a hernia knife, catch forceps retractors, scissors, ligatures and needles, silver wire

razor, sponges, chloroform, a half grain morphia suppository, antiseptic dressings, &c. The patient's bladder is to be emptied, the parts shaved and soaked with some antiseptic solution. He is laid on his back, with his shoulders somewhat raised, and the knee of the affected side slightly bent over a pillow; no more of his body should be uncovered than is absolutely necessary. The spray being turned on, an incision of sufficient length is made over the neck of the sac obliquely downwards and inwards, the centre of the incision corresponding to the external abdominal ring. To make the incision, the skin is pinched up at each side of the proposed site between the fingers and thumbs of an assistant, or the Surgeon may take one side, the assistant the other; the Surgeon then transfixes this fold, the back of the knife being towards the hernia, the knife being then made to cut its way out. When the parts recover their normal position a linear incision is left. The dissection is then carried carefully down through the various layers of tissue, all bleeding vessels being at once tied or twisted. As the Surgeon approaches the sac, and in all cases of doubt, the different layers must be opened in the same way as the sheath of an artery is opened; Spence's hernia director is then slipped in, and the layer slit opened by a probe pointed bistoury. The sac is known by its rounded tense appearance, filamentous character, and by the arborescent arrangement of vessels on its surface, it is bluish in appearance, and it may be possible to see fluid and the intestines through it. In all cases of doubt, open *as if it were* the sac. The gut wall is smooth and polished, probably congested, but has no arborescent vascular network; but should the sac be opened

inadvertently fluid will escape, and the doughy granular omentum protrude.

The sac in all small hernia should be opened at its *lower part*, because in this position there is usually some fluid which protects the bowel from injury; in large herniæ the *neck* of the sac must be opened. If the sac is not very tense take it between the finger and thumb and displace the contents, and then pinch a small part up by the forceps, and divide it with the edge of the scalpel held horizontally; a director is then introduced, and the opening enlarged by a probe-pointed bistoury, and then each side of the opened sac seized by a pair of catch forceps. If the fluid is clear and transparent, or slightly yellowish, like serum, and has no bad odour, the prognosis is good, as it indicates that the inflammation has not been of very long standing or severe; the gut will probably be found deep red and glistening. Some hours later the fluid is dark brown in colour, the gut purple but still glistening. Still later the fluid resembles a strong infusion of coffee, the gut is purple or black, and the *glisten lost*; it has a sodden appearance like wet parchment, or is ash-grey in colour. When the fluid has a very bad odour it probably indicates gangrene, and the prognosis is bad; should bubbles of gas escape it indicates perforation or putrefaction. In dividing the constriction the finger is the best director; it is passed up into the sac (the left index finger) and the nail slipped under the tight edge of the constricting band; the hernia knife is then passed along its palmar surface, lying flat upon it, till it is passed through the constriction, and has the cutting edge opposite that point. The blade is then turned for about a quarter of a circle, with its edge pointing in the proper direction,

and the sharp edge of the constriction is in this way notched, and the finger is then passed into the abdomen to feel that all is clear. The contents must now be examined. The gut is pulled down a little way, and the part where the compression was applied carefully examined; it may either be at once returned or left in the wound. The *colour* is of little consequence provided the natural gloss of the gut is not lost, and as long as this glisten remains the gut may be put back into the abdomen; if in doubt relieve the constriction and let the gut lie in the wound. If it has an ashy-grey softened look, and the glistening appearance gone, then it must not be put back, but must be left in the wound. *Recent* **adhesions** may be torn through, old ones ligatured, if necessary, and cut. The **omentum** may either be returned, or left in the sac to plug up the orifice, or ligatured, and a part cut off, according to its condition and size. The neck of the sac is then to be tied, and the walls of the canal drawn together by silver wire or catgut sutures. The wound is then closed, and a catgut drain or small tube introduced at its lower angle, and a good broad antiseptic dressing applied, with plenty of wool, and the whole steadied by a domet spica. The patient is then put to bed and kept warm, and a dose of opium administered either by the mouth or hypodermically. He must not be purged, but the bowels left to act of themselves, or at the most a castor oil and gruel enema given.

Accidents of the operation are, wound of the gut, or wound of some of the vessels near the openings. The operation is sometimes followed by peritonitis.

Reduction en masse or bloc.—By this is meant the return of the sac and its contents into the

abdomen, still in a state of strangulation, or, in any case, the external protrusion made to disappear somewhere, whether *into* the abdomen or not. It may be pushed into the extra-peritoneal tissue or between the fascia transversalis and the muscles. But it probably also includes other conditions, as cases where the bowel bursts through a hole in the neck of the sac, but the hernia is still strangulated by the mouth of the sac.

Reduction en bissac.—In some cases an intra-parietal sac exists as a diverticulum from the ordinary sac, and the hernia is displaced into it instead of into the abdomen.

After the gut is apparently reduced, the **Symptoms of Strangulation may still persist. Causes**—(1) It may have been reduced *en masse*. (2) A strangulation may have existed within the sac while taxis only overcame the external strangulating cause, *e.g.*, a kink of bowel through a hole in the omentum. (3) The nipped segment of gut remains in a state of paralysis from acute inflammation. (4) Reduction en bissac, or the sac may have been hour-glass shaped, one part in and the other outside the abdomen, and the gut is simply displaced from the one to the other. (5) A second strangulated hernia may exist at some other aperture. (6) The gut may have ruptured; and (7) acute peritonitis may have been set up. Two courses are open for the Surgeon—either to cut down upon the canal, and see what has gone wrong, or else perform laparotomy, having made sure of the absence of a second hernia and peritonitis.

Taxis in Inguinal Hernia.—In the operation of taxis (that is, reducing the hernia by manipulation)

the parts should be relaxed as much as possible; and for this purpose the shoulders should be raised and the lower extremities flexed at the hip and knee and adducted. The neck of the hernia should be steadied with one hand, while pressure is made in the direction of the canal with the other. A warm bath and chloroform will assist the operation considerably, but it must not be carried out too vigorously or for too long a period, if the constriction does not yield. In children, however, it is important to remember that the canal is not oblique.

RADICAL CURE OF HERNIA

1. A Truss.—PROFESSOR CHIENE strongly insists that a properly-fitting and properly-worn truss ought to be a *radical* cure, instead of a *palliative* measure, as it is usually called. If the bowel is prevented from passing down, by pressure of sufficient amount and at the same time properly directed, nature will do the rest. The canal has a natural tendency to contract and close, and it is only the occasional passage of the gut that prevents it. A properly applied and properly fitting truss *constantly* worn, most nearly approaches nature's method of cure. The pressure must be applied directly to the neck of the sac and the internal abdominal ring, and must be just of sufficient amount to keep up the hernia; if it is too powerful it will induce atrophy of the walls of the canal. All that is wanted is to allow the neck of the sac to close. The pressure must not be nipple-shaped, but *flat*, so as to keep the walls in contact throughout their whole extent. The pad must be as large as possible, provided it does not press upon the spine of the pubes, for then the hernia would slip

out beneath it, nor must it interfere with the flexion of the hip joint. It should be light, firm, and elastic, and well-fitted; *ready-made* trusses are an unmixed evil. It must be worn night and day (or, at night, a properly-applied elastic spica, with cotton wool below it, may be used if the truss is uncomfortable, but the truss must be put on *before* the patient gets out of bed in the morning); a special gum-elastic truss must be worn when taking a bath. In almost every case, and certainly always in children, a double-headed truss should be used. Femoral hernia is the worst to manage, as it is very difficult, or almost impossible, to press on the neck of the sac; in these cases an 'opposite-sided' truss (Salmon & Ody), or Spence's triangular-shaped pad, must be used.

Measurements and Directions to be sent to Instrument Maker in regard to a Truss.—It is better always to send the patient, if possible, both to be measured and to get it 'fitted on' afterwards. The great difficulty is to find intelligent instrument-makers, who are able, or willing, to comprehend the idea, or principles involved, in making and fitting a truss, and who are at the same time willing to follow the Surgeon's directions.

Measure (1) the circumference of the body midway between the great trochanter and the anterior superior iliac spine; (2) the distance between the anterior superior spine and the hernial aperture. It would probably be better to take a rigid cast of the two sides of the pelvis by means of a strip of lead, and then mark this on paper, and send it too, as well as the other measurements. Also send (3) the size and shape of pad; (4) the direction of the pressure; and

(5) the kind of the hernia and the side on which it occurs.

To Test the Truss.—The patient should sit on the edge of a chair, with his legs widely apart, his body bent forwards, and then cough forcibly.

(2) **Wurtzer's.**—This consists in the agglutination of the neck of the hernial sac by exciting inflammation in it, and closure of the canal by the invagination of the scrotum, which is fastened into the inguinal canal by a plug of wood; along the interior of the plug (which is hollow) a flexible steel gilt needle is pushed, and is made to traverse the invaginated scrotum, hernial sac (the contents of the sac being previously reduced), and the anterior abdominal wall, through which it protrudes. A concave wooden case is then passed over the projecting point of the needle, and screwed tight, so as to compress the enclosed tissues; inflammation is thus excited, and the scrotal plug may remain *in situ* for a time. *Objections.*—(1) It is apt to set up dangerous peritonitis; (2) Frequent failure in complete occlusion of the canal, the plug almost always descending after any exertion. For these reasons the operation is now generally abandoned.

(3) **Wood's Operation** consists in drawing together the tendinous structures forming the boundaries of the canal by subcutaneous (?) wire suture, with or without the invagination of a piece of the scrotal fascia, detached subcutaneously from the skin, to protect the sac, and held there by the wire suture till adhesion occurs. The left forefinger is passed beneath the margin of the conjoined tendon and triangular fascia (these two being in the posterior wall of the canal), and a needle is thrust through,

armed with a wire suture, and afterwards through two points of the anterior wall of the canal—the internal and external pillars of the ring—and these four points are then drawn together, thus occluding the canal.

(4) **Spanton's Method.**—He closes the canal by screwing in, from above downwards, an instrument closely resembling an ordinary corkscrew. It is left in from seven to ten days.

(5) At the present time, however, the operations for the radical cure usually include **ligature of the neck of the sac.** The sac may then be cut off, and the ligatured opening allowed to slip back into the abdomen; the walls of the canal and the external ring are then drawn together by silver wire, silk, or catgut sutures. The above should always form part of any operation for the relief of strangulated or irreducible hernia.

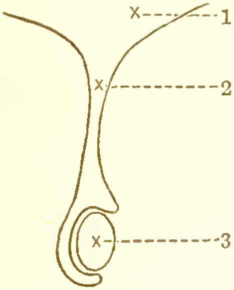
OTHER VARIETIES OF INGUINAL HERNIA.

(1) **Congenital**, or hernia in the sac of the tunica vaginalis. The hernia in this case lies inside the tunica vaginalis, and therefore in contact with the testicle; it is always oblique, and takes the same course as the testicle. The possibility of its occurrence is due to the fact that the process of peritoneum (processus vaginalis) which passes down before the testicle into the scrotum, has not become obliterated as in the normal condition, but remains open (Fig. 64) and thus serves as a medium of communication between the general cavity of the peritoneum and the tunica vaginalis, through which the congenital hernia descends.

(2) **Encysted, or Infantile Hernia.**—The hernia in

this case passes down *behind* the tunica vaginalis, and is due to the fact that the *processus vaginalis* is only obliterated at the internal abdominal ring

Fig. 64.

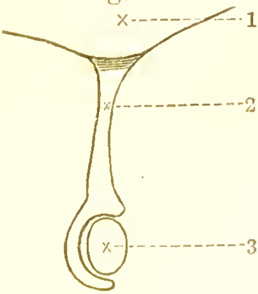


CONDITION OF THE PROCESSUS VAGINALIS IN CONGENITAL HERNIA.

1. Abdominal cavity. 2. Processus vaginalis. 3. Testicle.

(Fig. 65), and the gut passes down behind the large tunica vaginalis, or invaginates it. Should strangulation occur in this form, in the operation for its relief,

Fig. 65.



CONDITION OF THE PROCESSUS VAGINALIS IN INFANTILE HERNIA.

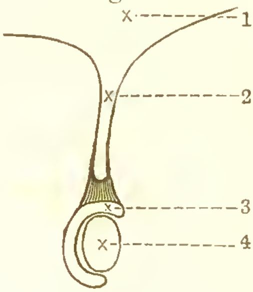
1. Peritoneal cavity. 2. Unobliterated part of the vaginal process. 3. Testicle.

the Surgeon will have to pass through *both layers of the tunica vaginalis* before he reaches the neck of the sac, and the layer forming the anterior wall of the

sac before he reaches the hernia, or three layers in all. (3) **Hernia into the funicular process.**—In this case the *processus vaginalis* is only obliterated close to the testicle, leaving the whole up part open (Fig. 66), into which the gut descends.

In the female there is a process of peritoneum that passes down along the round ligament, corresponding to the processus vaginalis of the male, and is known as the **Canal of Nuck**; from the presence of this structure, the female is occasionally the subject of acquired or congenital inguinal hernia.

Fig. 66.



CONDITION OF THE PROCESSUS VAGINALIS IN FUNICULAR HERNIA.

1. Abdominal cavity. 2. Unobliterated part of the vaginal process. 3. Cavity of the tunica vaginalis. 4. Testicle.

The *contents* of the hernial sac vary. If it consist of the intestine alone, it is called an *Enterocele*. It is usually some part of the small intestine, most frequently the ileum, sometimes the caput cæcum of the large. Hernia of the omentum is called *Epiplocele*. Hernia of both intestine and omentum together, is called an *Entero-epiplocele*.

FEMORAL HERNIA.

It will be well at this point to say a word or two

about the anterior part of the fascia lata of the thigh and the saphenous opening. The fascia consists of (1) An *iliac* part lying external to the saphenous opening; and, (2) A *pubic* part lying internal to the same opening. The *iliac* part is attached to the crest of the ilium, anterior superior spine, Poupart's ligament, and the pectineal line, and becomes continuous below with the pubic part. From the pectineal line and spine of pubes it is reflected down, forming the superior cornu and the falciform process of the saphenous opening. The *pubic* part is attached above to the pectineal line, internally to the margin of the pubic arch; it passes *beneath* the sheath of the femoral vessels binding down the psoas and iliacus muscles, and is then lost on the capsule of the hip joint. At the lower part it becomes continuous with the iliac part, and at the point where the two meet they form the inferior cornu of the saphenous opening. The iliac part thus passes in *front* of the femoral vessels, while the pubic part passes *behind* them, and between the two is the *saphenous opening*. This is an oval opening at the upper and inner part of the thigh, just below the inner end of Poupart's ligament, and is produced by the above splitting and folding of the fascia lata of the thigh. It is directed obliquely downwards, forwards, and inwards; its length is an inch and a-half, and its width about half an inch. Its lower margin is well defined, and is called the *inferior cornu*; its upper margin, the *superior cornu*: its outer edge, the falciform process of Burns; its inner edge, however, is ill defined, and lies, as we have seen, on a plane posterior to the outer edge, passing behind the femoral vessels. There is a strong band of fibres

passing between the superior cornu of the falciform border of the saphenous opening and Gimbernat's ligament; this band is known as the femoral ligament of Hey. This so-called opening, however, in the recent state, is covered by the *cribriform* or sieve-like fascia—this fascia being perforated by a large number of lymphatic vessels, hence the name. If the fascia lata and the cribriform fascia be reflected, the *femoral sheath* is exposed (Fig. 52, 3); the anterior part of this sheath is a continuation of the fascia transversalis lining the abdominal wall, and passing down beneath Poupart's ligament; the posterior part of the sheath is a continuation of the fascia iliaca also from the abdomen. On the anterior part of this sheath there are a few thickened transverse bands of fascia just below Poupart's ligament, which are called the "*deep crural arch*" (the "*superficial crural arch*" being Poupart's ligament). The *femoral* or *crural* sheath is funnel-shaped, being too wide just beneath Poupart's ligament, but closely adherent to the vessels about one inch below the saphenous opening; it is divided into three compartments, by septa passing from the anterior to the posterior wall—the *external* contains the femoral artery, the *middle* the femoral vein, while the *inner* contains, and is closed by condensed areolar tissue, a lymphatic gland and some lymphatic vessels and fat, the whole mass being called the *septum crurale*, and the compartment containing them the *crural canal*. This canal is, therefore, situated between the femoral vein and the inner wall of the crural sheath. It extends from the *crural ring* to the upper part of the saphenous opening, and is about half an inch in length. Boundaries of the

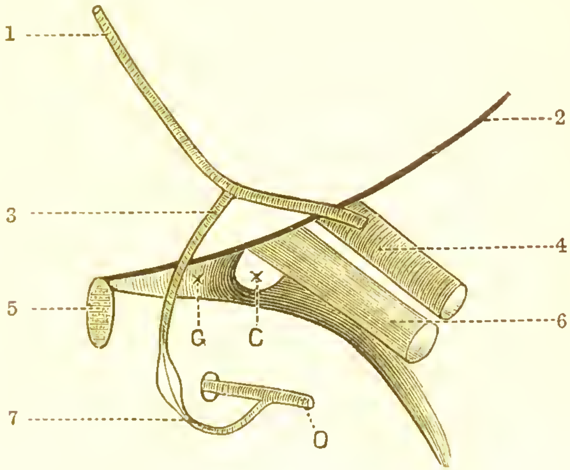
Canal.—*Anterior wall*, the fascia transversalis, Poupart's ligament, and the falciform process of the fascia lata; *posterior wall*, the iliac fascia and the pubic part of the fascia lata; *outer wall*, the fibrous septum covering the inner side of the vein; the *inner wall*, the inner side of the femoral sheath. **Boundaries of the Crural Ring.**—In *front*, Poupart's ligament, and deep crural arch; *behind*, the body of the pubes, covered by the pectineus and the fascia iliaca; on the *inner* side, the sharp border of Gimbernat's ligament, conjoined tendon, and fascia transversalis; on the *outer* side, the femoral vein, covered by its sheath. Femoral hernia is more common in women (1) because the distance between the iliac and pubic spines is greater, and Gimbernat's ligament is smaller; and for these reasons the femoral ring is larger; (2) from changes in the abdominal viscera during pregnancy. The *coverings* of this form of hernia are—(1) the skin; (2) superficial fascia; (3) cribriform fascia; (4) the femoral sheath; (5) crural septum, which is equivalent to the extra-peritoneal cellular tissue and fat; (6) the peritoneum. The **fascia propria** is the anterior part of the crural sheath fused with the septum crurale. In reducing femoral hernia by **taxis**, it is necessary (1) to bear in mind the course of the hernia, and (2) to put the limb in such a position that the falciform process of the saphenous opening will be relaxed. The hernia enters the crural ring, passes down the crural canal, and escapes by the saphenous opening—at first passing downwards and forwards, and then upwards; and, therefore, in applying pressure, it must be directed downwards, backwards, and upwards; and to relax the falciform margin

of the saphenous opening, the thigh must be flexed on the abdomen, adducted, and rotated inwards. The hernia is directed upwards on account of the close attachment of the superficial fascia to the lower margin of the saphenous opening, which thus prevents its further descent. The seat of stricture in femoral hernia is usually the sharp edge of Gimbernat's ligament.

Operation for Strangulated Femoral Hernia.—The superficial structures are divided by a vertical or a T-shaped **incision.** The vertical limb of the incision is made over the inner side of the neck of the tumour; it may be two or three inches long, and its centre must correspond to the upper part of the saphenous opening. The horizontal limb is made parallel with Poupart's ligament, and immediately below it. The various coverings are carefully divided till the sac is reached; and the finger is then passed along the canal till the stricture is found, which is relieved by cutting cautiously upwards and inwards, so as to notch or divide both Gimbernat's and Hey's ligaments: if this cannot be accomplished by the extra-peritoneal method, the sac must be opened at the *lower* part and the stricture divided from within it. The section is made in this direction not only for the reason given above, but for other reasons: thus, if the section were made outwards, the femoral vein is in danger; if upwards and outwards, the epigastric artery; and if directly upwards, the spermatic cord might be cut. The great danger is in the possible abnormal origin of the obturator artery, which may come in the way of the inward incision. The blood-vessels near the crural ring under normal conditions

are (Fig. 67)—(1) The femoral vein, to its outer side; (2) The deep epigastric artery, to the front and outer side of the opening; (3) The pubic branch of the deep epigastric, also in front, and passing inwards over it. The obturator artery usually arises from the anterior division of the internal iliac artery, and

Fig. 67.



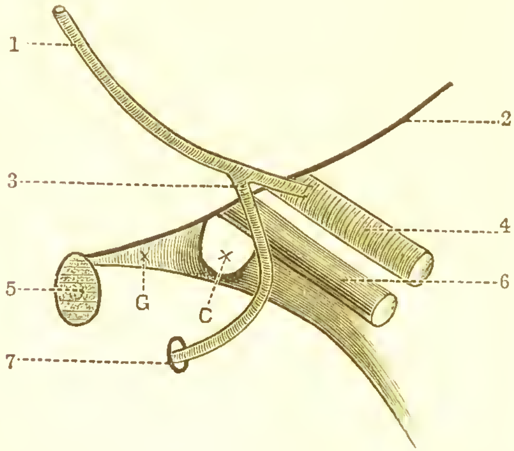
VESSELS NEAR CRURAL RING—NORMAL.

1. Deep epigastric. 2. Poupart's ligament. 3. Pubic branch of the deep epigastric. 4. External iliac. 5. Symphysis pubis. 6. External iliac vein. 7. Pubic branch of obturator. C. Crural ring. G. Gimbernat's ligament. O. Obturator artery.

escapes from the pelvis by the upper part of the obturator foramen; but this artery sometimes arises from the deep epigastric, and, when it does so, it is usually the pubic branch very much enlarged. In order to reach the obturator foramen, it may pass in either of two directions—(1) It may pass down close to the vein, and external to the crural ring, in one out of every four cases (Fig. 68) (WOOD); or (2) It

may arch over the crural ring, and descend internal to it, in about one out of every eighty cases (Fig. 69). It is in this latter variety that the danger exists, because, in cutting inwards on Gimbernat's ligament, the vessel is also apt to be divided or wounded ; but, fortunately, this variety of abnormal distribution of the artery is not very common, and this is all the more fortunate because it is impossible to foresee or

Fig. 68.



ABERRANT OBTURATOR—NON-DANGEROUS VARIETY.

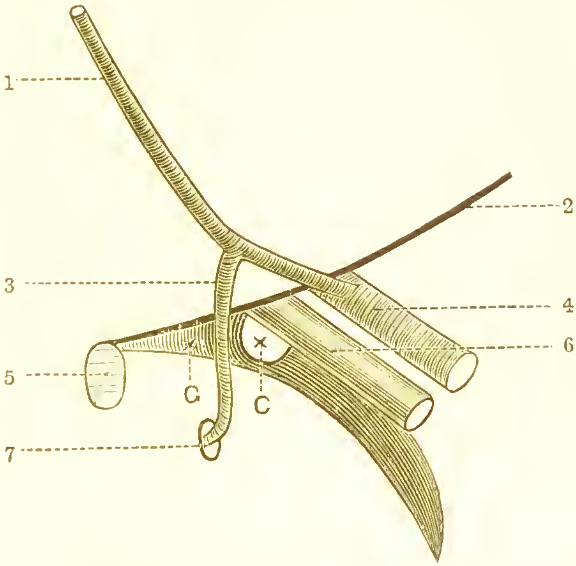
1. Deep epigastric. 2. Poupart's ligament. 3. Aberrant obturator. 4. External iliac artery. 5. Symphysis pubis. 6. External iliac vein. 7. Obturator opening. C. Crural ring. G. Gimbernat's ligament.

avoid the accident. In the diagnosis between this form of hernia and the inguinal form, it is well to remember that the neck of the sac in femoral hernia is situated below Poupart's ligament, and external to the spine of the pubes ; whereas in inguinal hernia the neck of the sac is above Poupart's ligament, and internal to the pubic spine.

Littré's Strangulated Hernia.—In this case only a *part* of the circumference of the bowel is involved. It is always femoral, and usually occurs in women.

Obturator Hernia.—This is a rare form, and very often is not detected during life: it usually occurs in women. It may be possible to feel it per vaginam,

Fig. 69.



ABERRANT OBTURATOR—DANGEROUS VARIETY.

1. Deep epigastric. 2. Poupart's ligament. 3. Aberrant obturator. 4. External iliac artery. 5. Symphysis pubis. 6. External iliac vein. 7. Obturator opening. C. Crural ring. G. Gimbernat's ligament.

and it causes a slight fulness, or actual tumour, at the inner and upper part of Scarpa's triangle. When strangulated, the obturator nerve is pressed on, and there is pain down the inner side of the thigh, and at the knee joint. In likely cases it will be justifiable to incise and explore; the **incision** should be parallel with the femoral artery, and on the adductor longus

muscle. The fascia lata and pectineus muscle must be divided.

Umbilical Hernia.—This form—'starting of the navel'—is pretty common in children; in the adult it is more usually ventral, and not exactly at the umbilicus. It occurs in stout bellied people usually, and comes through some of the fibrous septa, such as the linea semilunaris or linea transversæ, but very rarely *at* the umbilicus. It is supposed that the apertures through which the vessels pass, cause the *local weakness*, necessary for the production of any form of hernia. It usually forms a large tumour, which rapidly becomes irreducible from omental adhesions. In the child, the coverings are often very thin, consisting of little else than the integument of the umbilical cord —the contents consist for the most part of bowel; in the adult the coverings are thicker. Umbilical hernia in the adult (or ventral) has a great tendency to become incarcerated, but very little tendency to strangulation, as the opening is usually large, and there is no neck to the sac. In the child the opening readily closes, if the bowel be kept in the abdomen for a few months by a broad flat pad; in the child, this form of hernia never strangulates, and never causes death. Should it become strangulated in the adult, it is always at the lower part of the hernia, where it is sharply bent over the fascial aperture from its own weight. Operations are not very successful or safe in this form of hernia, probably from the proximity to the great nervous plexuses, and the peritoneal sac, and the bowels are apt to protrude during the operation, and considerably embarrass the operator. It is only to be undertaken

when no other means can give relief. Formerly, the patients often succumbed to septic peritonitis; now-a-days this risk is greatly diminished.

Ventral Hernia.—By this is meant a hernia through any part of the abdominal wall, except the inguinal, the femoral, or the umbilical apertures.

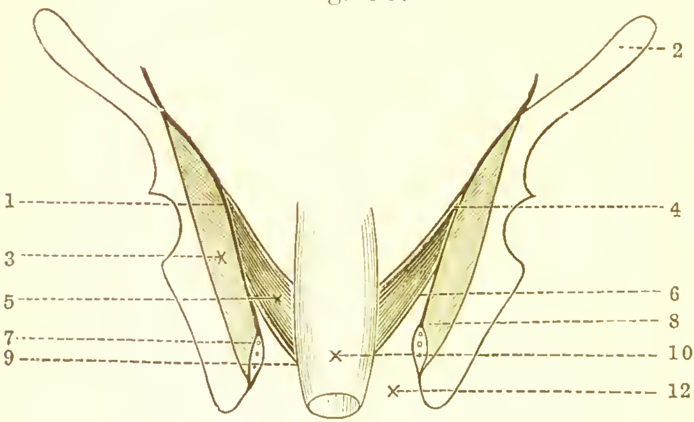
THE PERINÆUM.

Dissection of the Perinæum.—The **anatomical** perinæum corresponds to the inferior outlet of the pelvis, and in shape resembles an heraldic lozenge, and has the following **boundaries**:—In *front*, the symphysis pubis and sub-pubic ligament; *laterally*, in front, the divergent rami of the pubic arch and tuberosities of the ischia; laterally, behind, the convergent great sacro-sciatic ligaments, overlapped by the glutei maximi muscles; and *behind* by the tip of the coccyx. The space is divided into two parts by a line passing from the anterior border of one tuberosity of the ischium to the other; the posterior division is called the rectal part, and the anterior division the urethral. The **surgical** perinæum does not extend so far back; it must be regarded as ending at the 'central point of the perinæum'—the point where the terminal prolongation of the triangular ligament is attached, and where the superficial perineal fascia turns round the transversus perinæi muscle to be attached to the base of the triangular ligament. All beyond this point is to be regarded as ischio-rectal fossa, or the *rectal part* of the anatomical perinæum.

The Posterior or Rectal Part.—This part is the same in both sexes, and contains the lower end of the rectum and tip of the coccyx; and on either side

there is a space known as the 'ischio-rectal fossa.' Each space is pyramidal in shape, and has the following boundaries:—Its *base* is formed by the skin and fascia covering it; its *apex* by the meeting of the outer and inner walls; the *outer* wall is the obturator fascia covering the obturator internus muscle, and giving a sheath to the internal pudic artery; the *inner* wall is the fascia covering the levator ani and

Fig. 70.



ISCHIO-RECTAL FOSSA.

1. Position of the 'white line.' 2. Os innominatum. 3. Obturator internus muscle. 4. Rectal layer of pelvic fascia. 5. Levator ani muscle. 6. Anal fascia. 7. Pudic vessels and nerve. 8. Obturator fascia. 9. Point at which the abscess usually bursts into the rectum. 10. Rectum. 12. Ischio-rectal fossa.

external sphincter muscles; the *anterior* wall is formed by the base of the triangular ligament and transverse perinæal muscle; the *posterior* wall is formed by the gluteus maximus, great sacro-sciatic ligament, and the coccygeus muscle. The *contents* of the space are—(1) Twigs of the small sciatic nerve; (2) Inferior hæmorrhoidal nerve; (3) The fourth sacral nerve, to the external sphincter; (4) Super-

ficial perinæal nerves; (5) Inferior hæmorrhoidal vessels; (6) Much loose granular fat, which forms a movable elastic packing for the rectum. Abscesses may form in this space; and unless they are early and freely opened, they will either burst into the interior of the gut or spread widely upon the nates, being unable to 'point' readily at the base of the space on account of the strong fascia covering it. In opening abscesses in this region, the knife should be directed so as to cut towards the anus, parallel with the radii of a circle of which the anus is the centre, to avoid, as far as possible, division of the vessels and nerves of the space, which radiate towards the anus. This space is also concerned in the various forms of **fistula in ano**, which frequently arise from abscess in this region; and in the complete form of fistula the structures between it and the rectum must be divided, so as to lay the two cavities into one, before a cure can be effected. In this operation the structures divided will be—(1) the integumentary coverings; (2) sphincter ani, and wall of rectum; (3) fatty tissue; (4) small blood vessels and nerves. As the great cause of persistence of this fistula is the constant movement of the parts, the section of the sphincter paralyses this movement, and gives the parts rest. It is worthy of notice that fistula in ano is very frequently associated with phthisis, perhaps in the first instance, due to the excessive coughing—in this condition it is probably better not to operate for the cure of the fistula, but rather simply to treat the constitutional cause. These fistulæ usually open into the bowel just above the sphincter, no matter in what part of the fossa the abscess arises. This

is because of the anal fascia which coats the levator ani, and which resists the passage of the abscess towards the rectal wall, so that the pus passes down by the side of the fascia, and perforates the rectal wall just about the point where the anal fascia joins it (Fig. 70). The ischio-rectal fossa is also opened into in the operation of lateral lithotomy.

The Anterior or Urethral Part.—It will be well here to say a few words about the *triangular ligament* of the urethra, or deep perinæal fascia. This is a ligament which fills up the pubic arch, and is, therefore, triangular in shape—hence its name; it divides the urethral triangle into superficial and deep parts. The urethra pierces it, but the penis is entirely in front of it, and the bulb lies in contact with its anterior surface. The so-called 'posterior layer' of the triangular ligament is simply a part of the parietal layer of the pelvic fascia attached to the posterior lips of the margin of the pubic arch, and below to the base of the true triangular ligament. By this means there is a small space enclosed, which is spoken of as the 'space between the two layers of the triangular ligament.' In the dissection of this part of the perinæum, after having reflected the skin, we come to the superficial fascia—in this region this has been divided into a superficial and a deep layer; but these two layers are practically one, only the layer has two distinct surfaces. This fascia is sometimes called the **fascia of Colles.**

Attachments of this Fascia.—*Laterally*, it is attached to the margins of the pubic arch, as far back as the tuberosities of the ischia; beyond this it is firmly blended with the fascia lata of the thigh; *behind*, it

bends round the transverse perineal muscle, and is attached to the base of the triangular ligament of the urethra; in *front* it is unattached, and is continuous with the fascia of the scrotum and penis, and in this way a pouch is formed which is open *above*. From the median line an incomplete septum projects downwards towards the urethra and into the scrotum. From the above attachments it is evident that extravasated urine cannot pass backwards into the posterior half of the perinæum—that is, the posterior half of the *anatomical* perinæum, or ischio-rectal fossa—because of its attachment to the base of the triangular ligament, nor down the thighs, because of its attachments to the pubic arch and fascia lata of thigh; but it will fill the pouch and pass into both sides of the scrotum, and then pass up the front of the abdomen, along the spermatic cord; and even when it has reached the abdomen it is still unable to pass down the thighs, because the superficial fascia of the abdomen is firmly attached to Poupart's ligament. Thus far in the dissection we have simply removed—(1) the skin; (2) the superficial fascia; and when the pouch above mentioned is opened into, we come to—(3) the long scrotal nerves—(*a*) anterior superficial perineal, (*b*), posterior superficial perineal, (*c*) the long pudendal; (4) blood-vessels—(*a*) the superficial perineal artery, (*b*) the transverse perineal artery. These structures being reflected, we then expose—(5) the superficial muscles of the space—three in number—which form a small triangle (the perineal triangle), the floor of which is formed by the triangular ligament. The muscles are—(*a*) the accelerator urinæ, lying on the penis; (*b*)

the erector penis, lying on the crus penis; and (*c*) the transversus perinæi. When these are removed, (6) the bulb (the dilated posterior part of the corpus spongiosum) and root of penis are exposed; and if they in turn be removed, (7) the anterior surface of the triangular ligament is exposed. (8) Remove the anterior layer of this ligament, and the structures between its two layers are exposed—viz.: (*a*) the membranous part of the urethra, surrounded by (*b*) the compressores urethræ (GUTHRIE's muscle), (*c*) the artery to the bulb, (*d*) the internal pudic artery, (*e*) Cowper's glands, (*f*) the pudic nerves, (*g*) the dorsal vein of the penis. Reflect these structures and cut through (9) the posterior layer of the triangular ligament, and (10) reflect the levator ani, and the prostate gland is exposed, surrounded by its capsule and the prostatic plexus of veins; and if the rectum be turned aside, (11) the base of the bladder, with the vesiculæ seminales and the vasa deferentia are exposed. There are various structures which pierce the anterior layer (that is, the *true* triangular ligament) of the triangular ligament—viz.: (1) the urethra, in the median line, one inch below the pubes; (2) the dorsal vein of the penis, also in the median line, half an inch below the pubes; (3) the internal pudic artery; (4) the dorsal nerve of the penis; (5) the artery to the bulb.

In relation to the subject of extravasation of urine from rupture of the membranous part of the urethra (the usual seat of tramatic rupture), it is difficult to see how the urine can spread as it does, because the space between the two layers of the triangular ligament, where the membranous urethra

is situated, is practically a closed membranous box. It has been suggested that the urine passes forwards by the side of the structures that pierce the anterior layer, but the subject requires further investigation.

The Anterior Space in the Female.—In the female there is situated in this space the orifice of the vagina, and the parts connected with it—the true perinæum in the female being that part between the posterior commissure of the labia and the orifice of the anus, and is from an inch to an inch and a half in length. A work of this kind is not quite the place to take up the subject of development; still, a few words on it will not be amiss, in order to trace out the homologous parts in the two sexes. Up to the seventh or eighth week of fœtal life, in both sexes the genital, urinary, and intestinal tubes open into a common opening, or cloaca, a condition which is permanent in reptiles and birds. About this time a transverse partition forms, dividing this cloacal aperture into an anal or posterior division, and an anterior division, called the *uro-genital sinus.* From the part of this sinus lying above the opening of the Wolffian duct in the male, and the Müllerian duct in the female, the prostatic portion of the male urethra, and the *whole* of the female urethra, is developed; the part below this, forms the vestibule in the female, and the membranous part of the urethra in the male. The uro-genital sinus is, however, further sub-divided by a fold forming in the antero-posterior direction, called the *genital eminence*, and which ultimately forms the penis in the male and the clitoris in the female. The under surface of this body is cleft, and it is further bounded by two folds,

which in the male grow down and close in the furrow, forming the corpus spongiosum of the penis ; but in the female they remain open, and, diverging from each other, form the nymphæ or labia minora. At the sides of the sinus other integumentary folds arise, which in the male join to form the scrotum ; but in the female they remain open, and form the labia majora. In the male, the small prostatic pouch or *sinus pocularis*, seen in the prostatic portion of the urethra, is the homologue of the vagina and uterus in the female. This space further differs from the corresponding space in the male—(1) Because the superficial fascia, owing to the position of the vulva, is divided in the middle line, and becomes continuous with the sheath of the vagina ; (2) Situated between the orifices of the vagina and the anus, is a structure known as the 'perinæal body,' which corresponds in position to the central point of the perinæum, but contains much elastic tissue ; (3) The two halves of the muscle, corresponding to the accelerator urinæ, in the male, are separated by the vulva, forming the bulbocavernosus muscle or sphincter vaginæ ; (4) The vagina pierces the triangular ligament of the urethra. (5) From the above it is evident that we cannot get 'extravasation of urine,' as in the male.

CHAPTER XXXVII.

THE PELVIS.

LITHOTOMY.

The Lateral Operation.—Instruments Required.— 1. **Sounds** of various kinds. The usual sound is a solid steel instrument, shaped like a catheter, but with a shorter curve, so that it may readily examine all parts of the bladder, especially the part behind the prostate; the handle is flattened, and the point slightly bulbous. SIR H. THOMSON'S sound is hollow, and has a round handle; it is thus more easily managed during rotation, and may be used either to inject, or draw off the contents of the bladder. 2. An eight-ounce, or Higginson's, **syringe** with a catheter for injecting the bladder (unless the hollow sound be used), and a tube for washing out the bladder through the wound after the operation, by a reversed current. 3. **Staffs** as large as the urethra will admit, with as deep and wide grooves as possible on the left hand side; the groove must stop half-an-inch from the point, and must not extend too far up the handle, lest urine escape during the operation. The broad part of the handle should be roughened. 4. **Knife** with a large handle, for the adult say about four and a half inches; the blade is about three inches long, and does not cut to the heel, the cutting edge only extending about

half way down the blade from the point. The blunt part is to allow the finger to be placed below the blade to press and keep the knife in the groove in the staff during the second part of the incision. A probe-pointed knife is sometimes used to enlarge the deeper part of the wound before the stone is extracted. ASTON KEY uses a straight staff at the latter part of the operation. BUCHANAN uses a rectangular staff: the angle is felt in the perinæum and the knife cuts straight down upon it, and then along the *straight* groove, into the bladder. 5. **Blunt gorget**, probe pointed, with blade about five or six inches long. This is sometimes useful as a director and safe guide for the forceps, and for dilating the already cut wound, and may be used in cases where the finger cannot reach the bladder, as in enlarged prostate, and in a fat person with a very deep perinæum. Sharp gorgets, formerly much used for cutting the deeper part of the wound, are now discarded. 6. **Forceps** of various sizes, straight, or curved, to suit the axis of the pelvis; the blades, when closed, should be about an eighth of an inch from each other. The handles have a ring on one side, and a loop on the other; the ring is for the thumb, the hook for the fingers. 7. **Scoops.** 8. **Searcher**, specially made for such, or else use an ordinary sound. 9. It may be sometimes necessary to have some means present for crushing the stone. 10. A pair of **lithotomy tapes** of worsted or coarse flannel, three yards long, and three inches broad; or leather anklets and wrist bands may be used. 11. A silver, or gum elastic, **rigid tube**, well rounded at the end, and provided with rings, whereby it can be tied into the bladder, with or without 'petticoats.' There

are also specially made 'air tampoon' tubes for the same purpose. The tube with the petticoat or air bag is specially adapted for plugging the wound in cases of deep venous hæmorrhage, and being *rigid*, the walls of the tube are not squeezed together, so that the urine and discharges can still pass freely through. This tube is not to drain the wound, and must therefore only have holes at its ends; if the wound requires to be drained, then a special drainage tube must be used.

12. **Catch forceps**, tenacula, ligatures, sponges, lint, morphia suppository (half-grain), towels, etc.

Assistants.—Three special assistants are required—**one** to steady and adduct each knee, and a **third** to hold the staff and pull the scrotum up out of the way. This assistant stands on the left side of the patient, close behind the assistant holding the left knee; he is also to grasp both scrotum and penis with his left hand, and pull them up, for by so doing he not only holds the scrotum out of the operator's way, but by stretching the penis, he also draws up the bulb, which is thus less likely to be wounded. The **Surgeon** is seated on a low stool facing the patient's buttocks, so that when operating his fore-arms are almost on a level with the patient's perinæum; the instruments are arranged in a convenient manner on a tray within easy reach, or else committed to the charge of an assistant.

If necessary, the bowels must be opened the previous day, by means of an aperient; the left side of the perinæum may also be shaved, as this will save trouble on the morning of the operation. On the morning of the operation, the rectum must be emptied by an enema of warm water, administered two hours or so before the operation; it is necessary

to see that it acts properly before the operation, lest it act when the patient is on the table, and besides, a distended rectum adds greatly to the risk of the operation. The urine is allowed to collect for an hour or so before the operation, or else five or six ounces of tepid carbolised water must be injected. The patient being now placed on the table, an anæsthetic is administered, the sound passed, and the *stone struck*, the 'click' being heard both by the operator and his assistants; if the stone is detected, he proceeds with the operation, but if he cannot detect it, the operation *must* be abandoned for that day at least, for the law is that this operation must never be performed unless the stone can be felt, when the patient is on the table, and this law, like the laws of the Medes and Persians, altereth not. In sounding, the patient lies on his back upon a hard mattrass or table, with his buttocks a little elevated, by means of a pillow, and the bladder moderately distended with urine. A full-sized sound, well warmed and oiled, is then allowed to enter the bladder by its own weight. When it has entered the bladder, the point is made to move gently from side to side, then from before backwards; it is next rotated slightly with the beak downwards, and the handle gently depressed between the patient's thighs, so as to examine the floor of the bladder and the part immediately behind the prostate. The handle may be depressed still further, and the beak turned upwards, so as to examine the pubic portion of the bladder wall. The usual positions of the stone are:—(*a*) at the right side of the neck of the bladder; (*b*) at the fundus, near one or other ureter; (*c*) in

the pouch behind the prostate, especially in old men; and (*d*) more rarely in a pouch under the pubes, or in the posterior and upper wall. Besides proving the actual existence of a stone, the sound assists in ascertaining the size, number, situation, and density.

The stone having been felt by the staff, the patient must then be firmly tied up in the usual lithotomy position, and during the manipulations necessary for this purpose, the staff must not be allowed to slip out of the bladder. This is done by making a clove hitch in the tape and passing it round the wrist, after which the palm of the hand is laid against the upper and outer surface of the patient's foot, and fastened there by the ends of the tape being passed in a figure of eight round the ankle, instep, and hand, and firmly tied. The patient is then moved downwards to the end of the table, so that his buttocks project slightly over its edge. Each leg is firmly held by an assistant, who faces the operator, placing one hand on the inner side of the patient's knee, which is placed under his arm, while with the other the foot is grasped and drawn backwards and outwards. The staff assistant stands on the left side behind the other assistant; the staff must be held very steadily, exactly in the middle line, and at right angles to the long axis of the patient's trunk, and hooked vertically upwards against the under surface of the pubes. This steadies the staff; the surface of the staff nearest the operator rests against the palmar surface of the assistant's fingers, while the palmar surface of his thumb presses against the broad roughened part of the handle. It will further contribute to greater steadiness if the elbow of that arm be allowed to rest *lightly* on the patient's

thorax; this must not be done to such an extent as to impede the respiratory movements of the patient. The staff must on no account be allowed to tilt either towards or from the abdomen; if it is tilted towards the abdomen, then its point leaves the bladder, and, of course, the knife cannot enter it; if it is tilted towards the perinæum it enters the bladder too far, and there is a risk of the knife entering the posterior wall. The Surgeon now passes his finger into the rectum to ascertain the depth of the perinæum by feeling the apex of the prostate and membranous portion of the urethra, to see that the rectum is empty, and also to make it contract to its fullest possible extent, which will keep it out of the way. The fingers of the left hand are then laid on the left side of the perinæum, to steady it while the first incision is being made. The knife is entered one third of an inch to the left of the median raphé, about an inch and a-half in front of the anus, and is carried downwards and outwards for about three inches to a point between the anus and the tuberosity of the ischium, but rather nearer to the tuberosity than it is to the anus. The deepest part of this incision should be at the upper part, just between the erector penis, covering the crus, and the accelerator urinæ covering the bulb, and must become shallower and shallower as it passes downwards into the ischio-rectal fossa. In making this incision the point of the knife should strike the staff as it lies between the 'two layers' of the triangular ligament in the membranous portion of the urethra. In making this incision, PROFESSOR CHIENE keeps his finger in the rectum, all the time resting on the apex of the prostate, while he steadies the

tissues outside with his thumb; there is no doubt but that by this means the depth of the perinæum and the situation of the staff in the membranous urethra can be more easily kept in the mind's eye, and that, therefore, the first incision is more safely and correctly made. By this incision we divide—(1) the skin; (2) superficial fascia, opening into the pouch formed by the fascia of Colles; (3) the inferior hæmorrhoidal vessels and nerves; (4) probably some branches of the long scrotal nerves; (5) the transversus perinæi muscle; (6) the anterior layer of the triangular ligament, lower border; (7) the membranous urethra surrounded by the compressores urethræ muscles. The left forefinger is then to be passed into the wound, to see that the staff is reached; then the nail of that finger is placed in the groove in such a way that the dorsal surface of the finger is turned towards the operator's right hand. The knife is then slipped along the finger, and its point pushed through the membranous urethra into the groove of the staff while the finger protects and pushes aside the rectum. The blade of the knife is then inclined till it lies parallel with the rami of the pubes and ischium, the point slightly above the level of the handle, and is then pushed steadily along the groove into the bladder, taking care not to depress the handle too much, lest the opening in the prostate may be made too large, nor elevating it lest it slip from the groove altogether. Just as in ligature of arteries, the principle here is to make a free superficial incision, but a limited deep incision. The opening in the prostate may be enlarged as far as necessary when removing

the knife, by depressing the handle. As the knife is withdrawn, the operator pushes his finger along the groove in the staff into the bladder—(*a*) to plug up the wound and prevent the escape of fluid; (*b*) to feel the stone and judge its size and turn it in the proper axis for the forceps; (*c*) to dilate the prostatic incision; and (*d*) to judge what size of forceps is most suitable. The structures divided in this second incision are—(1) the rest of the membranous urethra and the compressores urethræ muscles; (2) a few fibres of the levator ani (*levator prostatæ*); (3) the left lobe of the prostate, and the prostatic portion of the urethra; (4) a dense ring which surrounds the prostatic urethra; (5) the internal sphincter of the urethra (*sphincter vesicæ*). As soon as the finger feels the stone the staff is withdrawn. The forceps are then introduced, the finger already in the bladder acting as the guide; the blades are separated a little, so as to embrace the finger upon the *dorsal* surface of which they are pushed through the prostate into the bladder, as the finger is withdrawn. Sir H. THOMSON directs that they should be passed along the palmar aspect of the finger, till they are fairly in the bladder. The blades are then opened, and the stone is usually caught, being carried between the blades by the first gush of urine. If the stone be faceted, there will almost certainly be others present: the searcher must be used to explore the whole cavity, and make sure that they are all removed. Small ones may be removed by the scoop, being grasped between the blade of the scoop and the point of the operator's finger. All bleeding arteries are then secured, the venous hæmorrhage usually soon

stops of itself. The wound is then washed out, and the rigid gum elastic tube tied in, the patient loosened and carried to bed. He is placed on a firm mattrass, guarded by water-proof cloth; a draw sheet is placed beneath his buttocks. Each knee, slightly flexed and abducted, should lie on a pillow. A special attendant must watch the wound and the discharges, and see that the tube does not become blocked up by blood clots. A dose of opium may be given if necessary. When the patient makes plenty of urine, this is always to be regarded as a very good sign. The diet should at first be non-stimulating, consisting chiefly of milk, with plenty of barley water to drink. The urine passes at first entirely through the wound, but after the end of the first day it may pass several times by the urethra. After forty-eight hours, it again passes entirely through the wound; about this time the rigid tube is to be removed, as by this time the sides of the wound are glazed, so that there is no danger of urinary infiltration, and besides, if left longer, it is likely to become coated with phosphatic deposit. After eight or ten days it begins to pass by the urethra, and in about three weeks after the operation it ceases to pass by the wound altogether. There is no risk of stricture following this wound of the urethra, because the incision is longitudinal, or in the long axis of the tube, and not transverse (DUNCAN). In boys, the operation differs somewhat from the same operation in adults. In the adult the bladder is easily opened into, but the difficulty is the removal of the stone; in boys, on the other hand, the stone is easily extracted, but the difficulty is to open into the bladder (CHEENE). This

difference depends upon the relative position of the bladder, and the size of the prostate gland in the child and in the adult. In the child the bladder is chiefly an abdominal organ, and the prostate gland is not yet developed.

The Following Facts are Worthy of Special Note:— In making the deeper incisions the side of the knife should be kept parallel with the ramus of the ischium, because if the edge be turned too much towards the mesial line (1) the rectum may be wounded; and if the edge be turned too much outwards (2) the internal pudic artery may be cut, which is bound down in a strong sheath of obturator fascia under cover of the ramus and tuberosity of the ischium; (3) The artery to the bulb, instead of coming off from the internal pudic, between the two layers of the triangular ligament, and running traversely inwards to the bulb, sometimes arises further back, and sometimes even in the ischio-rectal fossa, and in this case it is almost certain to be wounded, and this accident is attended with considerable danger to life, from hæmorrhage, for three reasons—(*a*) From its size, and from the fact that it is cut (usually) near its origin from the parent trunk; (*b*) It is so deeply placed that it is almost impossible to apply a ligature; and, (*c*) The fibrous nature of the tissues in which it lies at this point tends to prevent its contraction, and the consequent natural arrest of the hæmorrhage; the proper course is to enlarge the wound and tie both ends of the bleeding vessel. (4) The incision into the prostate should be as limited as possible, lest the knife pass beyond it and cut through the reflection of the pelvic fascia from its sides and front (the point of reflection,

however, is close to the *upper* part of the prostate), forming the lateral and anterior true ligaments of the bladder, and thus open into the pelvic cavity, which accident is almost certain to be followed by infiltration of urine and diffuse inflammation; (5) The bulb must be avoided; (6) If the knife be thrust too deeply in the last stage of the incision, the posterior wall of the bladder might be wounded. In performing lithotomy in children, there are certain differences in the size and position of the parts concerned—(1) The urethra is proportionately larger; (2) The perinæum is more vascular usually; (3) The rudimentary state of the prostate gland; (4) The bladder in children is situated much higher, being rather an abdominal than a pelvic viscus; (5) If the point of the knife is not raised sufficiently in making the deep part of the incision, the bladder may not be entered at all, but the knife may pass between the bladder and the rectum, and in attempting to dilate the supposed wound, the neck of the bladder may be torn from the urethra. With these differences in mind, the operation is performed in the same way as in the adult.

THE MEDIAN OPERATION.

In this case the incision is made in the middle line, in the space between the rectum behind, and the bulb in front. A staff, with a median groove, is passed into the bladder, and the left index finger passed into the rectum, and made to touch and rest on the apex of the prostate gland. The knife is then entered with its edge directed upwards, half an inch in front of the anus, and its point so directed that it cuts a small part of the apex of the prostate, and the membranous urethra; it

is then made to cut forward for a little way, opening the membranous urethra a little more fully. A ball-pointed probe is then passed along the staff into the bladder and the staff withdrawn. The finger is then introduced and the prostate gland dilated sufficiently, if this be possible; this operation has been characterised as, 'small incision, much dilatation,' but it is doubtful whether it is altogether 'dilatation.' After dilatation is completed the stone is extracted with the forceps.

Advantages—(1) It is said to be more easily performed; (2) there is less bleeding, as it is in the median raphé, and there is no risk of cutting the artery to the bulb; (3) it is said to be *impossible* to open up the visceral layer of the pelvic fascia, as it is dilatation, not cutting; there is less injury to the lateral ligaments of the bladder. **Disadvantages**—(1) Danger of wounding the bulb; (2) danger of wounding the rectum, both greater than in lateral; (3) the space is small and it cannot be used for large stones; the dense ring which surrounds the urethra prevents great dilatation, both in the prostate and at the neck of the bladder; (4) it cannot be used in the child, as probably the neck of the bladder would be torn from the urethra during the 'dilatation,' and besides there is practically no prostate in the child. It is **recommended** in cases of (1) foreign bodies in the bladder; (2) in cases of small stone, less than one inch in diameter, where 'crushing' cannot be used, *e.g.*, as for cystitis; (3) in cases of numerous small stones, or after lithotrity where fragments are left; (4) in cases where loss of blood is a serious matter to the patient.

The Bilateral Operation.—In this operation a curved transverse incision is made half an inch above the anus,

towards which its concavity looks, the extremities of the incision extending for about two-thirds of the distance between the anus and the tuber ischii on each side. By this incision there is divided—(1) skin; (2) superficial fascia; (3) superficial nerves of the perinæum; (4) superficial vessels of the perinæum; (5) the superficial muscles of the perinæum (see dissection of perinæum); (6) membranous portion of the urethra and the compressor urethræ muscle. Into this opening the double *lithotome caché* is introduced and passed into the bladder along a grooved median staff, with its concavity upwards; but when once in the bladder the concavity is turned downwards, the spring in the handle is pressed, and the blades, previously 'set,' are made to cut their way out in withdrawing the instrument. Through the opening thus made in the prostate the stone is extracted.

THE HIGH OR SUPRA-PUBIC OPERATION.

It may be necessary to perform this operation—(1) on account of the large size of the stone; (2) rigid hip joint; (3) contracted pelvic outlet. The bladder *must* be distended with twelve or sixteen ounces of some warm antiseptic, so that it can be felt above the pubes; if it cannot hold water then this operation cannot be performed. An elastic ring may be passed round the penis to prevent its escape. This may be accomplished through a silver catheter, the opening of which is securely plugged, and the instrument left in the bladder to serve as a guide during the latter part of the operation; or it may be taken out and a staff introduced for the same purpose. The patient rests on his back, with his pelvis raised four or five inches, so as to allow the

bowels to gravitate upwards and not press on the bladder; his legs are allowed to hang over the end of the table. An *incision* two and a half or three inches is made in the median line immediately above or partly over the pubes, so as to reach that part of the bladder which is uncovered by peritoneum. In cutting down to the bladder at this point, the **structures divided** are —(1) the skin; (2) the superficial fascia; (3) sheath of the recti, and the adjoining edges of the recti and pyramidales are then separated, and with the finger or the handle of the knife separate the loose cellular and fatty tissue, and divide (4) the transversalis fascia, and the anterior surface of the bladder is exposed. Make out, if possible, the reflection of the peritoneum, and then depress the handle of the staff which is in the bladder so as to project its point above the pubes, and open the bladder by cutting down upon this as guide. The opening is then enlarged downwards, the forceps introduced, and the stone extracted. A distensible air bag is sometimes introduced into the rectum to push the bladder forward and upward, and also to steady it. The wound may then be closed, both in the abdomen and in the bladder, and the urine drained off by a siphon per urethram; or both may be left open and a drainage tube passed into the fundus of the bladder and left there for a week or ten days. The chief dangers of this operation are—(1) the risk of infiltration of urine into the cellular tissue of the wound; (2) the risk of wounding the peritoneum.

LITHOTRITY.

In this operation the stone is crushed in the bladder, and the pulverised fragments expelled or extracted

through the urethra. The instrument used for this purpose is called a *lithotrite*; the operation was formerly performed at several sittings, and the shorter these sittings were the better, because the long continued contact of instruments with the mucous membrane of the bladder is apt to produce cystitis, leading to pyæmia, or even death. At the first sitting the stone was simply crushed and the fragments were left to be pulverised and extracted at subsequent sittings. But the crushed stone thus left is apt to produce great irritation in the mucous membrane of the bladder, and unless care be taken in the treatment of the patient between the sittings, small fragments of the stone are apt to be driven into the neck of the bladder, or even into the urethra, causing great pain and injury to the tissues; and, even with the greatest care in the *final exploration*, small fragments were apt to be left which formed the nuclei of subsequent calculi. Quite recently (speaking in 1882) a new operation has been introduced, called Litholapaxy, by Bigelow, who was the first to plan and carry out the operation. For its performance the following special instruments are required (1) a lithotrite; (2) a large evacuation catheter; (3) an aspirating siphon. The following advantages are claimed for this operation (1) The stone is crushed and removed at a *single sitting*, so that the bladder is thus freed from the irritation caused by small fragments of stone retained in its interior for a lengthened period, and the urethra is also freed from the irritation of their possible passage between the sittings (as in lithotrity); and, further, the fragments are completely removed, so that none are left to form the nuclei of subsequent calculi; (2) the

lithotrite lock is more easily closed than in the ordinary lithotrite, being closed by a simple turn of the wrist without displacing the hands, and the blades are so formed that they allow of the easy escape of detritus, so that laceration of the neck of the bladder is prevented in the withdrawal of the instrument; (3) the stone need not be *pulverised*, because, (4) the catheter used is very large, its inventor taking advantage of the fact that the urethra admits of great dilatation.

This is the operation that is always performed now, under the name of **Lithotrity at a single sitting**; the old lithotrity is a thing of the past. In the great majority of cases of stone, lithotrity is the operation performed for their cure; according to Sir H. Thomson it is *the* operation for nine-tenths of adult cases of stone. The special **instruments** required are (1) a set of large evacuating catheters; (2) an exhausting syringe; (3) a lithotrite.

Conditions Necessary for Crushing.—(1) A bladder not too irritable, it must be able to retain at least three or four ounces of urine; (2) kidneys, prostate, and urethra healthy; there must be no stricture of the urethra present. (3) The patient must not be too young; under fifteen years lithotomy is usually to be preferred. (4) The stone must not be too large or too hard; the size is not of so much moment, but a very hard stone is a serious objection. (5) Several calculi are rather against crushing, especially if they are hard. The **patient** is placed on his back on a firm mattrass or table, with his pelvis raised above the level of the shoulders by a firm pad, three or four inches thick, so that the stone may roll to the posterior surface of the bladder; a pillow is placed under his head and his

thighs are separated so that his knees are about a foot apart. In children, and in cases of enlarged prostate, it may be necessary to raise the pelvis a couple of inches more. The **Surgeon** stands on the right side of the patient. An anæsthetic should be administered. The urine is first drawn off by a hollow sound, or catheter, and then four or five ounces of tepid carbolised water is slowly injected; the urine is drawn off to enable the Surgeon to tell how much fluid there is in the bladder. Too much is bad, because the stone readily moves about and 'dodges' the lithotrite; yet it must contain a fair amount to prevent the mucous membrane from being grasped by the lithotrite, or being injured by the splinters of the stone. To **pass the lithotrite**—It is warmed and oiled and the blades closed and pointed downwards; the penis is then raised by the left hand and drawn over the lithotrite, which is held almost parallel with the abdomen at this stage. It thus descends to the bulb, the shaft becoming gradually perpendicular; it is *not* to be depressed at this stage, as is usual when passing a catheter, as this would make the blades impinge upon the upper wall of the urethra in front of the triangular ligament, and probably rupture the urethra. It is kept perpendicular and allowed almost to pass by its own weight till the point reaches the prostatic urethra, and *then* the handle is depressed and the instrument enters the bladder. To **catch the stone** two plans may be adopted—(1) To make the lithotrite hunt for the stone (CIVIALE'S, or the Continental plan); the stone is first felt by the closed lithotrite, which is then opened and the blades turned down upon the stone, just as a bird picks up a stone with his beak; this method may be

necessary occasionally in picking up stones behind an enlarged prostate, but is not so good as the next method. (2) To make the stone come to the lithotrite (Brodie's, or the English method). The lithotrite is never shifted from the mesial plane; it rests in the middle line, the blades are then opened wide, the under one depressed when the stone rolls into its grasp. The stone must not be crushed in this position, but the lithotrite must first be raised to make sure that no mucous membrane is grasped; it is then screwed home gradually and completely. The instrument must never be withdrawn till the blades are screwed completely home, otherwise fragments are left between the blades and lacerate the neck of the bladder and urethra. The fragments are then removed by means of the large evacuating catheters and aspirating siphon.

Calculus in the Female.—Stone is of rare occurrence in women. When it does occur it may be removed—(1) By *lithectasy*, *i.e.*, through the dilated urethra, dilated either—(*a*) By sponge tent, or dilator, or (*b*) by incising the mucous membrane; (2) by *lithotomy*—(*a*) suprapubic operation as in the male, (*b*) the urethral operation, by introducing a grooved staff and cutting along it into the bladder, (*c*) the *vaginal* operation, by cutting through the anterior wall of the vagina and base of the bladder; (3) by *lithotrity* or *litholapaxy*.

CHAPTER XXXVIII.

THE PELVIS *(Continued)*.

THE URETHRA.

Length.—The length of this canal in the male is from eight to nine inches; in the female it is only about an inch and a half in length, and corresponds, as we have seen, to the prostatic portion of the male urethra.

Divisions.—In the male it is divided into three parts. (*a*) *the prostatic portion.* This part is about an inch and a quarter in length, and passes almost directly downwards, but slightly forwards. It is situated about the middle of the prostate gland, but rather nearer its anterior surface, and is in front of the middle lobe. In connection with it we notice the following parts:—(1) As it opens into the bladder there is a transverse fold of mucous membrane called the 'uvula vesicæ.' (2) Continuous with this there is a median ridge called the *crest* of the urethra, *caput gallinaginis* or *verumontanum.* (3) On either side of this crest there is a depression called the *prostatic sinus*, and in it may be seen the openings of numerous prostatic ducts; (4) at the summit of the crest there is a median opening called the *sinus pocularis*; and (5) at each side in the walls of the sinus are seen the openings of the *common ejaculatory ducts.* (*b*) *The membranous portion.*—The length of this part is—anterior wall, three-quarters of an inch;

posterior wall, half an inch. It is directed forwards and downwards, extending from the apex of the prostate gland to the bulbous portion of the urethra, and is contained between the two layers of the triangular ligament, the anterior layer of which it pierces, and is about an inch below the symphysis pubis. It is surrounded by the compressor urethræ muscle, and is the most frequent seat of *spasmodic* stricture. Spasmodic stricture, however, may occur at any part of the membranous or penile portion of the urethra, for the urethra is as truly a muscular tube as the œsophagus, and, like it, has a complete muscular coat. (*c*) *The spongy portion.*—The posterior part of this portion is sometimes called the *bulbous portion* from the fact that it is surrounded by the bulb of the urethra (which is simply the dilated posterior part of the corpus spongiosum, just as the glans penis is the dilated anterior part). The length of the spongy portion is from five to six inches (the bulbous part occupies about one inch of this). The direction of this part necessarily varies with the state of the penis; the bulb, however, is the lowest part of the whole canal, and into it the ducts of Cowper's glands open. The bulb is, further, the most frequent seat of *organic* stricture, probably because, being the lowest part, the inflammatory products tend to accumulate at this point. Along the floor of the spongy portion proper numerous mucous follicles open, their orifices being directed towards the meatus; there is also a large one in the roof of that part of the urethra situated in the glans penis, and is called the *lacuna magna*, and this one must be avoided in passing a catheter.

Size and Shape of the Urethra.—The urethra, as

we have already pointed out, admits of considerable dilatation, so that no exact measurement is obtainable of its absolute size; we can, however, compare the size of one part with another. When closed, it is simply a slit—at the anterior part the slit is *vertical*, further back, the slit is *transverse*, while in the prostatic portion, the slit is *curved* with its concavity downwards, as seen on transverse section. It is narrowest at the meatus, and the next narrowest part is at the junction of the membranous with the spongy portion—*i.e.*, as it pierces the triangular ligament (anterior layer). If the *prostatic* part be distended it is seen to be fusiform in shape, being widest in the middle, and a little contracted at each end; the *membranous* portion is the narrowest. The *bulbous* part of the spongy portion is dilated; it then grows somewhat smaller, but expands again in the glans penis to form the *fossa navicularis*, and then contracts to form the meatus.

Curves of the Urethra.—In the flaccid condition of the penis, the general course of the urethra somewhat resembles the letter S lying on its side, but when the penis is erect the anterior curve is obliterated, and hence this is called the *temporary* curve; the *permanent* curve, however, remains under all circumstances, and we have thus two curves—(1) the temporary, and (2) the permanent, and to this latter the curve of the catheter corresponds. The permanent curve is maintained by—(1) the pelvic fascia fixing the neck of the bladder and the prostate gland; (2) the connection of the root of the penis with the pubes by means of the suspensory ligament of the penis; (3) the two layers of the triangular ligament fixing the membranous part; (4) the connection of the base of the triangular liga-

ment with the superficial fascia of the perinæum, and through it to the 'central point of the perinæum.' It is of importance to remember that, with the finger in the rectum, the bulb, membranous part of the urethra, prostate gland, and even the base of the bladder beyond, may be felt. These parts are more easily distinguished if a catheter be previously introduced; and in this way the fact of having made a false passage may be detected, the catheter not being found in the bladder, nor bearing the proper relation to the parts in question. To be right, the cathether should be felt exactly in the middle line, with the prostate gland and the rectal wall between it and the finger; in false passages it will probably not be in the middle line, and the finger will recognise only a *thin* layer of tissue between it and the catheter.

Organic Stricture is due to the organisation of a plastic exudation thrown out into the *submucous* tissue; this is transformed into fibrous tissue, which gradually contracts and closes the canal. The usual **causes** are—(1) *inflammation* (usually gonorrhœal, but may occasionally follow non-specific urethritis); (2) *Traumatism*, as rupture of the urethra from falling across a spar with the legs apart, when the urethra is snipped across between the pubic arch and the spar. The traumatic stricture is the worst of all forms, and is very frequently situated in the membranous part of the urethra: probably 99 per cent. arise from gonorrhœa. **Locality.**—according to Sir H. Thomson—(1) 67 per cent. are found near the junction of the bulbous, with the membranous portions; (2) at or near the external orifice, 17 per cent.; (3) 16 per cent. between these two points. It is well to note that stricture is not found in the

prostatic part of the urethra; examiners find some difficulty in believing in the existence of prostatic stricture, notwithstanding they are told of it so repeatedly. One of the earliest **signs** of stricture is frequency of micturition, especially at night. In examining an unknown urethra to ascertain the existence, or otherwise, of stricture, always begin with a good sized instrument—say No. 10.

I will only but very briefly indicate the **treatment** In most cases **dilatation** by the ordinary method will be found sufficient. An instrument as large as the patient can comfortably bear is passed the first day; then at intervals of from three to four days larger sizes are passed, till the meatus will admit no larger size—perhaps from 14-16 English size. The instruments are taken out as soon as passed, and after getting a warm drink and half an hour to an hour's horizontal rest, the patient may be allowed to depart; it is well to warn him on the first occasion that he will find the stricture worse the following day (from the inflammatory effusion) but by the third day he will be all right. In passing catheters the **rule** is—*to pass the size below the largest one passed on the patient's previous visit, and never to miss a size.*

Resilient Stricture.—By this is meant strictures that very readily dilate up to the full size, but very speedily return again to the contracted condition. In this case it is impossible and useless to treat them by the above method; it was for such as these that Mr Holt introduced his method of 'splitting' the stricture by a special wedge-shaped instrument. The risk is that the mucous membrane of the urethra will also be split, and leave a surface for septic absorption.

Perinæal Section (Syme).—This method of external urethrotomy is employed in obstinate cases of stricture, where there are at the same time large and numerous fistulæ and great induration of the perinæum, and the condition refuses to improve after a fair trial of rest, and drawing off the urine by the catheter. The **Instruments required** are—Scalpels and bistouries, catheters silver and gum elastic and red rubber, tubing to fit catheter, probes straight and curved, Syme's shouldered staff, lithotomy tapes, a large number of Wells's forceps, ligatures, sponges, &c. The **patient** is tied up in the lithotomy position. The **assistants** required are the same as in lithotomy. Syme's staff is then passed; the lower half of this staff is slender and grooved, but the upper part is of full size, and the shoulder, where the two parts meet, rests firmly against the face of the stricture, while the slender part passes through it into the bladder. An assistant holds the staff in his right hand and draws up the scrotum with his left, and the **operator**, seated on a low stool facing the patient's buttocks, makes an *incision* in the median raphé, from above downwards, about two inches long, and continues the dissection till he can distinguish the shoulder of the staff, which is the guide to the stricture. He then takes a sharp straight bistoury in his right hand, and holds the staff with his left, enters the point of the knife in the groove in the staff about one inch below the shoulder, and cuts upwards through the stricture; he next withdraws the staff about a quarter of an inch and extends the incision that much further forwards. If the stricture has been completely divided the thick part of the staff may now be passed through it: the

staff is then withdrawn and a large gum elastic catheter (10 or 12) passed and tied into the bladder, and a siphon arrangement attached to it by which the urine is continuously drained off. A morphia suppository is then introduced and the patient made comfortable in bed. At the end of forty-eight hours the catheter is withdrawn, and about three days later a full-sized bougie should be passed. Later it is passed once a week or once every two weeks, as circumstances may require. This operation may also be used instead of Holt's plan, in resilient stricture; the great advantage is that it gives the dilatation a good start, a full-sized instrument being passed at once, and all that is to do is to keep it from contracting again.

THE PROSTATE GLAND.

This gland is situated behind and below the pubes, embracing the neck of the bladder, and *lying against* the anterior wall of the rectum, the recto-vesical layer of pelvic fascia being the only structure that is interposed between the two. In size and shape it resembles a chestnut. It is closely connected with the anterior and lateral true ligaments of the bladder (pelvic fascia), which join it at its upper part, and for this reason the anterior ligament is called, at this point, the 'pubo-prostatic' ligament; between the two pubo-prostatic ligaments is the dorsal vein of the penis. It has also attached to it the anterior fibres of the levator ani muscle, these fibres being called, for this reason, the 'levator prostati.' It consists of three lobes—a median and two lateral. The middle lobe is the smallest of the three, and lies immediately below the prostatic portion of the urethra; it is pyriform in shape, and

when prominent the base projects into the bladder, forming the *uvula vesicæ*. In elderly men the prostate frequently becomes enlarged, and it is the middle lobe that seems to enlarge most, or whose enlargement gives rise to the most serious consequences. This is probably partly from its position, as its base will tend to grow in the direction of least resistance, that is, up into the bladder. The results of such enlargement are:—(1) a pouch is formed behind the projection, so that the urine tends to dribble away after it has passed in a full stream; in many cases, also, the urine lies in the pouch, and cannot be entirely expelled, and the unexpelled portion soon becomes decomposed and ammoniacal, and irritates the mucous membrane of the bladder, leading to chronic cystitis. (2) The projecting part may overlap the orifice of the urethra (which is normally the *lowest* point of the bladder), and act like a valve, preventing the passage of the urine through the urethral orifice, and the more the patient strains the tighter it becomes. (3) It alters the direction of the urethral tube, forming a little recess, and this must be kept in mind in passing a catheter, and special care taken to pass none but perfectly purified instruments: otherwise this well of urine is innoculated with septic matters, the probable result being the rapid onset of septicæmia.

In **structure** the gland consists of *glandular*, *fibrous*, and *muscular* elements in variable proportion; the 'hypertrophy' is probably in many cases due to an increase in the muscular tissue (non-striped), hence, perhaps, the value of ergot in this condition. It is enclosed in a dense fibrous *capsule* derived from the pelvic fascia—from the vesical, recto-vesical parts, and from the parietal layer as well. Beneath the capsule

lies a dense network of veins—the prostatic plexus—into which the dorsal vein of the penis empties itself. It is important to note that septic thrombosis sometimes follows operations in this region.

THE TESTICLE.

The Testicle: its Coverings.—*Hydrocele.*—The testicle lies obliquely in the scrotum, suspended by the spermatic cord and its coverings. It is oval in shape, and its front, sides, upper and lower ends, are smooth; but the *posterior* part, where the spermatic cord is attached, and where the vessels enter and leave, is not smooth, not being covered by the serous membrane (*visceral layer* of the *tunica vaginalis*). The gland itself is enclosed in a strong capsule—the *tunica albuginea*—which is a dense, fibrous membrane. *Coverings of the testicle as it lies in the scrotum.*—(1 The skin, which is thin and dark coloured, and usually in rugæ; (2) the superficial fascia, which in this region is peculiar in the fact that it contains no fat, but has a layer of non-striped muscular fibres—the *dartos muscle*; (3) the intercolumnar or external spermatic fascia; (4) the cremasteric muscle or fascia; (5) the infundibuliform fascia; (6) the *tunica vaginalis*, the special serous membrane of the testicle, which under normal conditions is entirely cut off from the peritoneal cavity. It consists of a visceral and a parietal layer: the *visceral* layer covers the front, sides, upper and lower ends of the testicle; but towards the posterior part it is reflected from the testicle, and becomes continuous with the parietal layer. The *parietal* layer is attached to the infundibuliform fascia by loose areolar tissue, and is more extensive than the visceral part, extending

higher up and lower down than the testicle. The tunica vaginalis, like other serous membranes, is a closed cavity, and it is of importance to remember that it is towards the *front* and *sides* of the testicle, so that the testicle seems suspended at the back of this serous sac; in the normal condition, however, its two layers are in contact. *Hydrocele of the Tunica vaginalis* consists of a collection of serous fluid *within the cavity* of this sac; as the fluid accumulates it forms a swelling at the front and sides of the testicle, and also passes up in front of the spermatic cord towards the external abdominal ring; it also passes down below the testicle, so that, if well marked, the testicle cannot be felt at the bottom of the scrotum. In tapping this distended sac grasp the tumour with the left hand so that the testicle lies in the centre of the palm and plunge the trocar, with a sudden thrust, into the most prominent part of the *front* of the scrotum, so as to avoid injury to the testicle which is usually at the posterior part; it is first plunged in perpendicularly, and then made to pass obliquely upwards. In tapping avoid large veins, and make sure that the case is not one of inversion of the testicle—*i.e.*, the testicle lying in front instead of at the back of the scrotum; further make sure that the condition is chronic. The position of the testicle may be made out by the aid of a candle and stethoscope, as well as by the 'testicular sensation.' When the sac is emptied, a solution of iodine is injected to set up inflammatory action to coat the serous surfaces with a layer of non-secreting lymph and prevent the re-accumulation of the fluid; it may also cause adhesion of the serous surfaces, but this is not the essential part of the cure, which is the destruc-

tion of the serous surfaces and deposition of non-secreting lymph. The most convenient preparation of iodine to use is *Tinctura Iodini* of the old Edinburgh Pharmacopœia; of this solution inject about two drachms. This tincture is stronger than the *Tr. Iodi* of the B. P., but not so strong as the liniment. After the solution is injected *the scrotum must be well shaken*, so as to bring it in contact with every part of the secreting surface. If, however, a communication exist between the cavity of the tunica vaginalis and the general peritoneal cavity, irritating fluids, like tincture of iodine, should not be injected lest they set up fatal peritonitis. In its passage the trocar pierces the following structures—(1) the skin; (2) the superficial fascia and dartos; (3) the intercolumnar fascia; (4) the cremasteric fascia; (5) the infundibuliform fascia; (6) the parietal layer of the tunica vaginalis. The epididymis is situated at the back and outer side of the testicle.

DIFFERENTIAL DIAGNOSIS BETWEEN HERNIA AND HYDROCELE OF TUNICA VAGINALIS.

Scrotal Hernia.	*Hydrocele.*
1. Tumour oblique in shape and direction.	1. Tumour, oval or pyriform.
2. The protrusion lies in front of and covers the spermatic cord, and testicle can be felt at the bottom of the scrotum. Scrotum cannot be folded up on the abdomen as in hydrocele (CHIENE).	2. The cord can be felt free in the inguinal canal at external ring, and the testicle cannot be felt at the bottom of the scrotum, but is situated behind.
3. An impulse is imparted to the tumour if the	3. No impulse on coughing; no gurgling at attempts

patient coughs; gurgling sound at attempts at reduction; percussion note clear (if intestine), but dull if omentum.	at reduction; percussion note dull. It is possible to feel the rounded *upper end* of the tumour.
4. No transparency on examination by the transmitted light of a candle.	4. Is usually transparent when thus examined.

In *Hæmatocele* (that is, a collection of blood in the tunica vaginalis,) the shape is usually globular, it is heavier than hydrocele, and hard or doughy to the touch, opaque to transmitted light, and dull on percussion. It may arise from a traumatism, when there will be marks of bruising in the tissues of the scrotum; or it may arise from a puncture of a vein during tapping for hydrocele, or from the bursting of a varicose vein.

Cirsocele or Varicocele is a varicose enlargement of the spermatic veins (the *plexus pampiniformis).* The left side is most frequently affected (1), because the vein of that side is longer; (2) it is apt to be pressed upon by fæculent accumulations in the sigmoid flexure of the colon; (3) it enters the left renal vein at right angles. It is usually found in young adults up to twenty-five years of age. The mass is pyramidal in shape with the base below; it feels like a 'bag of worms,' and it may be possible sometimes to see the dilated and tortuous veins. When he lies on his back it may disappear; if then the finger be pressed on the external ring and the patient made to stand up it will return in spite of the pressure; this distinguishes it from hernia.

Sarcocele.—By this is meant, merely a solid enlargement of the testicle. This may be—(*a*) **Simple,**

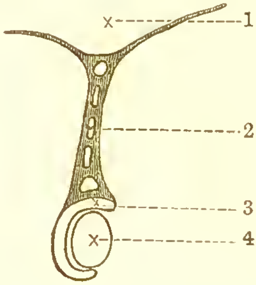
usually a form of chronic inflammation following acute orchitis, and affecting all parts of the testicle equally; it is smooth and uniform, and may be painful and tender. (*b*) **Tubercular**, affecting the epididymis and the vas deferens in the first instance, which become craggy and nodular, with perhaps soft spots here and there. (*c*) **Syphilitic**, a tertiary phenomenon appearing two to three years or longer after infection; the cord is healthy, the body of the testicle alone being affected, and is very often accompanied by hydrocele (*hydro-sarcocele*). There are two forms—(1) It may be a diffuse orchitis, or (2) it may be in the form of a localised gummatous tumour. (*d*) Tumours of the testicle, simple or malignant—as cystic sarcoma or chondro-sarcoma. Cancerous tumours are usually of the soft and rapidly-growing form, and begin in the body of one testicle and very rapidly infect the lumbar glands. The rapid growth and the absence of all inflammatory symptoms are suspicious.

VARIETIES OF HYDROCELE.

(1) **Of the Tunica Vaginalis**, already described, and consisting of an accumulation of fluid in the sac of the normal tunica vaginalis. The fluid is pale yellow, without smell. Neutral in reaction, and the specific gravity is about 1024, and it contains about six per cent. of albumen, and also contains fibrinogen. In old chronic cases it may have a glistening tint from cholesterine crystals. (2) **Congenital Hydrocele**, the *processus vaginalis* has remained open, so that a communication exists between the tunica vaginalis and the peritoneal cavity (Fig. 61). (3) **Infantile Hydrocele**.—In this form the *processus* has only closed at the internal

abdominal ring (Fig. 65). (4) **Encysted Hydrocele of the Cord.**—A dropsy of small unobliterated portions of the *processus;* it is obliterated at different parts of its course, leaving one or more closed sacs, which become distended with serum (Fig. 71). Or the processus may be closed at the upper and lower parts only, leaving the central part unobliterated; this condition is simply an arrest of a natural process. Normally the processus first closes at its upper part, and next at its lower part, and finally the intervening portion.

Fig. 71.



ENCYSTED HYDROCELE OF CORD.

To show the condition of the processus vaginalis in encysted hydrocele of the cord. 1. Abdominal cavity. 2. Unobliterated parts of the vaginal process which become distended with fluid. 3. Cavity of the tunica vaginalis. 4. Testicle.

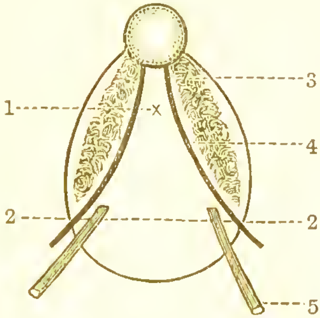
(5) **Encysted Hydrocele of the Epididymis.**—It may contain pure serum, but is more usually serum with a mixture of seminal fluid. The cyst is usually attached to the head of the epididymis. Its origin is doubtful; it may be (1) a dilated seminal tubule; (2) an enlargement of the '*Hydatid of Morgagni,*' which is the remains of the duct of Müller; (3) the organ of Giraldes—the remains of the Wolffian body or its duct, the *vas aberrans.* The fluid contains only a trace of albumen, and effervesces on adding an acid, from the

presence of alkaline carbonates; its opalescence is due to the presence of seminal fluid, and the spermatozoa may be recognised under the microscope.

THE BLADDER.

This is one of the pelvic viscera. When *empty* it lies entirely within that cavity behind the pubic bones and is of a *triangular* form; when *moderately distended* it is of a *rounded* form, and when *fully distended* it is *ovoid* in shape and rises above the pubes and

Fig. 72.



BASE OF BLADDER SHOWING THE TRIGONE.

1. Point at which to puncture the bladder per rectum. 2. 2. Line of peritoneal reflection. 3. Vesicula seminalis. 4. Vas deferens. 5. Ureter.

enters the hypogastric, or even the umbilical, region. Its relations to the prostate and rectum are given elsewhere.

Puncture of the Bladder.—This operation may be performed either from the rectum or above the pubes, and in doing so, advantage is taken of the anatomical facts that there is no peritoneum on the base of the bladder (that is, the part towards the rectum) nor on the antero-inferior surface. The part left uncovered

varies with the amount of distension of the organ. In tapping above the pubes, the bladder must be distended, so as to raise the reflection of the peritoneum well above the pubes; in tapping from the rectum, it must be done exactly in the middle line, and close to prostate. The part which may be punctured with safety is triangular in shape (the external trigone), and has the following **boundaries**:—On either side are the vasa deferentia (a vas on each side), and immediately beyond these, the vesiculæ seminales; the base of the triangle is formed by the line of reflection of the peritoneum on to the rectum, and at the apex of this triangle the prostate gland is situated. If the puncture be not in the middle line, the vasa deferentia or vesiculæ seminales may be injured; and unless well forwards towards the apex of the triangle, the peritoneum might be punctured. This operation may be rendered necessary for retention of urine in cases of stricture of the urethra, or in cases of rupture of the same structure, where it is impossible to pass a catheter.

Cock's Operation—or opening the urethra behind the stricture. The patient is tied up as for lithotomy. The operator then passes his left fore-finger into the rectum and places it upon the apex of the prostate, and then passes a broad, sharp-pointed, double-edged knife straight down to the apex, *exactly* in the middle line of the perinæum. The external wound is then enlarged somewhat, the knife withdrawn, and a probe-pointed director with a handle passed into the wound through the urethra and into the bladder; along this as guide, a tube is passed fitted with rings, whereby it can be tied into the bladder.

THE RECTUM.

The rectum extends from the left sacro-iliac synchondrosis obliquely downwards and to the right to the middle of the sacrum, and then curves forwards and inwards in front of the sacrum and coccyx; it then passes downwards and backwards from the tip of the coccyx to the orifice of the anus. It is divided into three parts—the *first* part extends from its commencement to the second or third sacral vertebra; the *second* part from the second or third sacral vertebra to the tip of the coccyx; the *third* part from the tip of the coccyx to the anal orifice—this part being about an inch and a half in length. The length of the entire rectum is about eight inches. **Relations.**—The *first part* is surrounded by peritoneum, which also binds it to the front of the sacrum as far down as the second or third sacral vertebra—this fold being known as the *meso-rectum*; in front of this part is the recto-vesical pouch of peritoneum and a part of the bladder in the male, but in the female the pouch of Douglas, the uterus, and the upper part of the posterior wall of the vagina. The *second part* is only partially surrounded by the peritoneum, the front and upper part of its sides alone being in relation to it; at its lower part the peritoneum is reflected, in the male, on to the back of the bladder, but in the female on to the posterior wall of the vagina. In the male, the base of the bladder lies immediately over this part, and between the two are the vesiculæ seminales and the vasa deferentia; but in the female the posterior vaginal wall is in relation to it. This part is attached by loose areolar tissue to the front of the sacrum and coccyx, and is also in relation to the

visceral layer of the pelvic fascia. The *third part* has no relation to the peritoneum, but is in close relation to the pelvic fascia and the levatores ani muscles, which support this part of the rectum; the rectal layer of the pelvic fascia joins the rectum about four inches from its lower end, and at the same time ensheaths the levatores ani; further, the recto-vesical layer of the pelvic fascia (or recto-vaginal layer in the female) is also in relation to the rectum. The prostate gland in the male is close to the commencement of this part, while in the female the perinæal body is in relation to its anterior surface throughout its whole extent, because at this point the rectum and the vagina diverge.

The Finger in the Rectum may feel the following—(1) the temperature of the part, as indicating the existence or otherwise of inflammation of the rectum itself or the parts near, such as the prostate; (2) the trigone of the bladder separated from the finger by the wall of the rectum with the rectal and recto-vesical layers of pelvic fascia with a packing of cellular tissue between; (3) the vesiculæ seminales and vasa deferentia; (4) the prostate gland; (5) the membranous part of the urethra passing from the apex of the prostate; (6) the triangular ligament proper, as a tight band stretching between the rami of the pubes and ischium. In relation to the prostate gland it is important to note whether it is hypertrophied: a weight of one ounce, or a measurement of two inches by one signifies hypertrophy. Also note the nodular, feel with soft spots here and there, characteristic of tubercular disease, and the large size and pulpy feel of encephaloid cancer sometimes met with in young boys. In regard to the vesiculæ seminales and vasa deferentia the chief point to note is the existence or not of tuber-

cular disease. (7) It is also possible to feel the obturator foramen, and of importance, therefore, in the obturator form of hernia. (8) The sacrum, coccyx, spines, and tuberosities of the ischium. I purposely avoid even naming the many wonderful things that the finger of the practised gynecologist can detect in this and the neighbouring passage.

Excision of the Rectum.—This operation may be performed for malignant disease, provided the patient is not too old or exhausted, if the finger can be passed beyond the disease, and if the diseased mass is freely moveable showing that it has not infiltrated neighbouring parts, especially towards the base of the bladder.

The bowel must be thoroughly emptied by an enema before the operation. The patient is placed in the ordinary lithotomy position, and a sharp-pointed bistoury is passed into the rectum, the point being brought out at the tip of the coccyx, and the parts between the anus and the coccyx divided by a single cut exactly in the middle line. If necessary the coccyx may be excised to give more room. During the operation all bleeding vessels must be seized at once by Wells's forceps. Ligatures are then passed into the two sides of the wound whereby the edges may be held apart during the subsequent steps. An incision is next carried round the anus from the margins of the wound, and the gut then separated from its posterior attachments by means of the finger and scissors; the sides are next dealt with, and then the gut is pulled backwards and carefully separated from its anterior connections, having previously passed a sound into the male bladder, and the finger into the vagina if the patient be a female, to act as guides. The gut itself must now be divided;

this may be done by the écraseur, scissors, or the thermo-cautery. According to HARRISON CRIPPS it is useless to attempt to bring down the mucous membrane of the divided gut to the anus, as the stitches always give way. The wound must be washed with chloride of zinc solution and sprinkled with iodoform: the wound is left to heal by granulation. The causes of death are chiefly peritonitis, pelvic cellulitis, and hæmorrhage.

The Pelvic Fascia.—This fascia consists of a *parietal* part, covering the walls of the pelvic cavity, and a *visceral* part, which connects the various pelvic viscera with each other and with the walls of the pelvis. The *parietal* part is attached to the brim of the true pelvis and the posterior surface of the pubic bones, and passes down into the pelvis, covering the obturator internus muscle, and is attached to the spine and tuberosity of the ischium; on the posterior pelvic wall it covers the pyriformis muscle and the sacral plexus of nerves, but is behind the internal iliac artery, the gluteal, sciatic, and pudic branches of which have to pierce it in order to escape from the pelvis. The *visceral* part is given off from the parietal layer, on a line with the spine of the ischium and the back of the pubes, the point where the two diverge being known as the 'white line.' The most anterior part passes backward to the *upper* surface of the prostate gland, forming the 'pubo-prostatic ligament,' and then passes on to the bladder, as the anterior true ligament of that viscus. The lateral part divides into three layers—the most superior forms the lateral true ligaments of the bladder, the middle passes between the base of the bladder and the rectum (the recto-vesical layer), while

the most inferior—the rectal layer—passes under the second and third parts of the rectum, and ensheaths the levator ani. The relation of that part of the parietal layer of pelvic fascia above the 'white line' (the 'undivided' pelvic fascia, of some) to the visceral layer, has been compared to that of the wall-paper and carpet of a room; and it is this carpet which must on no account be cut in the operation of lithotomy.

Pelvic Peritoneum. In the **Male**.—It completely invests the first part of the rectum, also forming the meso-rectum to this part, or the mesentery by which it is connected to the upper part of the sacrum; it next invests the sides and anterior aspect of the second part of the rectum, leaving it about three inches above the anus, and passing on to the lower and posterior surface of the bladder. It then passes forwards upon the posterior surface of the bladder, until it reaches its summit; it now leaves the bladder altogether, enveloping the urachus and lining the anterior abdominal wall. At the sides it covers the bladder as far as the level of the obliterated hypogastric arteries.

In the **Female**, between the rectum and the uterus, the peritoneum forms a pouch called the *Pouch of Douglas.* It also covers a small part of the upper end of the vagina, and the cervix, body, and fundus of the uterus, on the posterior aspect; at the sides it forms the broad ligaments of the uterus. In front it passes down to the level of the internal os of the uterus, and from that point is reflected on to the posterior surface of the bladder; the rest of its course is as in the male. The *Pouch of Douglas* is subdivided into three by means of two utero-rectal folds, formed by folds of peritoneum passing between the rectum and the

uterus; these folds contain the ureter, the obliterated hypogastric artery, the superior vesical artery and a mass of cellular tissue. The left division of the pouch is deeper than the right. In the **broad ligament** we find—(1) The round ligament of the uterus; (2) the Fallopian tube; (3) the ovary with its ligament, this order from before backwards; also (4) the parovarium; (5) the nerves, vessels, and lymphatics of the uterus and ovary; (6) a considerable quantity of loose cellular tissue, which is frequently the seat of pelvic cellulitis.

THE SPERMATIC CORD.

This structure extends from the internal abdominal ring, through the inguinal canal to the back part of the testicle. Its special **coverings** are—(1) The intercolumnar or external spermatic fascia; (2) the cremasteric fascia—consisting of fibrous tissue and muscle; (3) the internal spermatic or infundibuliform fascia, or fascia propria. The **component parts** are—(1) The vas deferens or excretory duct of the testicle; (2) three arteries—(*a*) the *spermatic*, from the abdominal aorta; (*b*) the *cremasteric*, from the deep epigastric; and (*c*) the artery to the *vas*, from the superior vesical; (3) the spermatic plexus of veins *(pampiniform plexus).* This plexus forms the chief mass of the cord and passes up in front of the vas, but at the upper part they collect into a single trunk which enters the abdomen through the internal ring, terminating on the right side in the inferior vena cava, but on the left side in the left renal vein. (4) Lymphatics, which terminate in the lumbar glands. (5) Nerves—(*a*) Sympathetic plexus; (*b*) the *genital* branch of the

genito-crural, which supplies the cremaster muscle. This fact explains the 'cremasteric reflex' best seen in boys—that is on tickling the inner side of the thigh over the distribution of the *crural* branch of the same nerve, the testicle of that side is observed to rise almost or quite up to the external abdominal ring.

The Vas Deferens can always be recognised by the hard, firm, whip-cord-like sensation it gives when the cord is held between the finger and thumb. It commences at the lower part of the globus minor and ascends along the posterior and *inner* side of the testis and epididymis and then along the *posterior* part of the cord; at the internal abdominal ring it lies to the *inner* side of the spermatic vessels, then hooks round the deep epigastric artery and descends upon the *inner* side of the external iliac vessels into the pelvis. It now passes downwards and backwards upon the side of the bladder, crossing to the outside of the obliterated hypogastric artery; it next passes to the *inner* side of the ureter and reaches the base of the bladder, where it becomes dilated and slightly sacculated, and lies, at the trigone, to the *inner* side of the corresponding seminal vesicle. At the base of the prostate it unites with the duct of the seminal vesicle to form the common ejaculatory duct; this duct runs forwards and upwards in the prostate and along the sides of the sinus pocularis, ending in a slit-like opening at the margin of the sinus in the prostatic urethra. Each vas is about two feet in length; the walls are very thick and dense, but the canal is extremely small. In describing the course of the vas note the *five* '*inners*.'

CASTRATION.

This may be required for malignant disease of the testicle, as cystic sarcoma, chondro-sarcoma (*'enchondroma'*), and the different forms of cancerous disease; also in 'simple' conditions that have resisted local and constitutional treatment, as large hernia testis, which is a source of annoyance and discomfort to the patient, some forms of syphilitic testicle, and in tubercular disease, to prevent systemic infection.

The pubes is shaved, having first made sure of the absence of hernia on the side to be operated upon, the **patient** is placed upon his back with his legs and thighs hanging over the end of the table. The **instruments required** are—Scalpel or straight bistoury, blunt hooks, sponges, ligatures, silk ligature for cord, aneurism needle, Wells's forceps, drainage tube, antiseptic dressings, scissors, chloroform, &c. The **Surgeon** stands between the patient's legs and grasps the posterior part of the testicle with his left hand so as to tighten the parts in front. In ordinary cases the **incision** should extend from the external abdominal ring to the bottom of the scrotum, in order to insure free access; if the tumour be large and the skin much stretched, so as to endanger its vitality, also in cases where it is involved by the malignant growth, two elliptical incisions should be made wide of the disease enclosing a part of the skin of the scrotum. The tunica vaginalis should be next opened, lest an old hæmatocele may have been mistaken for a solid tumour of the testicle, and the testicle itself must be examined before attacking the cord, lest the original diagnosis may be at fault, and it is too late to remedy mistakes

when the cord is divided. The testicle is then grasped with the left hand, while the coverings are shelled off with the right, and the firm fibrous mesorchium, stretching between the back of the testicle and the scrotum, divided by a touch of the scalpel. The cord is then isolated as high as thought necessary, and in the case of malignant disease it will be well to open up the inguinal canal upon a director, in order to go if possible above the furthest limits of the disease. In dividing the cord we are always warned to be careful lest it be pulled up into the inguinal canal before the vessels are tied, and so pass beyond the reach of easy ligature; the cause of this retraction is said to be the cremaster muscle. This muscle arises from Poupart's ligament, and is inserted into the spine of the pubes by a small tendon, and it is about as difficult to see how it can lift the cord above its insertion, as it is to imagine a man lifting himself by pulling upon the waistband of his trousers. The cord is grasped by two pairs of Wells's forceps, as it is too slippery to be held by the fingers of an assistant, and an *aneurism* needle, with a double ligature of stout silk, gradually passed through it; the ligature is then divided, and the cord tied in two halves or the Staffordshire knot may be used. Some tie it *en masse.* A *sharp* needle is not used to transfix the cord lest it puncture a vein and set up phlebitis; the ligature being passed *through* the cord prevents any risk of slipping. The arteries and veins of the cord are then tied or twisted separately. The cord is then divided half an inch below the ligature, and the testicle liberated by the fingers, aided by a touch of the knife. All bleeding vessels are then secured, especially in the

septum scroti, a drainage tube is introduced and brought out at the lowest part of the wound, and the incision closed with sutures. Should the operation be performed for tubercular disease the vas must be separated and divided as far up as possible, the operator bearing in mind the existence of the deep epigastric artery. The possible existence also of a patent processus vaginalis must be kept in mind, especially in the young, lest the injury set up fatal peritonitis.

The **dangers** of the operation are—erysipelas, peritonitis, simple or septic, and septic thrombosis.

THE PENIS.

The two *corpora cavernosa* form the chief bulk of the organ; they are placed side by side above, and in the groove below is lodged the *corpus spongiosum* which is pierced throughout its whole extent by the urethra. Cunningham facetiously likens the relation of the three parts to the two barrels and ramrod of a double-barrelled gun; only in this case it is not the *barrels* that are perforated but the *ramrod*. The *root* of the penis is formed by the bulb and the two crura. The *crura* are formed by the diverging corpora cavernosa, and are attached to the sides of the pubic arch; the *bulb* is formed by an expansion of the corpus spongiosum, and rests upon the anterior surface of the triangular ligament. Covering the bulb we find the *accelerator urinæ* muscle, while each crus is covered by the *erector penis* muscle of the corresponding side. In front the corpora cavernosa end in rounded extremities, which are overlapped by the glans penis—the expanded

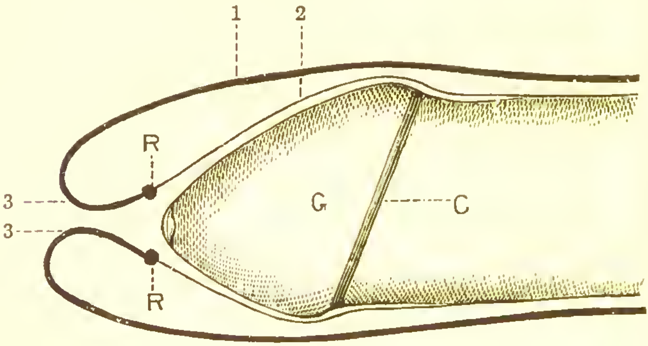
anterior end of the corpus spongiosum. The **prepuce** consists of two layers—an external or cutaneous layer, and an internal or mucous, or more properly, muco-cutaneous. The skin passes for a variable distance beyond the glans, and is then folded in upon itself forming the prepuce; the internal layer is attached to the sulcus behind the corona glandis, where it blends with mucous membrane covering the glans. Below the glans is the *frænum preputii* stretching from the lower angle of the meatus; in the frænum is a small vessel which, if wounded, may give rise to serious hæmorrhage. The free margin of the prepuce, just where the thin, red, and moist muco-cutaneous layer joins the cutaneous or outer layer, is the narrowest part of the opening of the prepuce, and it is this narrow ring that gives rise to the trouble in phimosis and paraphimosis. It is important to note this ring in reference to the operation of circumcision; the contraction is not of great breadth, being merely narrow and ring like, hence all that is required is to remove this ring, and if it is not removed it matters but little what else is taken away, the condition will not be relieved without a second operation.

Phimosis.—In this condition there is usually a long foreskin, the orifice of which is so contracted that it prevents exposure of the glans, and leads to the retention of the sebaceous secretion (smegma preputii, secreted by the glands of Tyson), setting up local irritation and inflammation, and may even prevent the patient making water properly. The condition may be congenital, or acquired, usually the result of inflammation or disease.

Circumcision is performed for the relief of the above conditions. In performing the operation bear in mind

what has already been stated about the relations of the cutaneous and mucous parts of the prepuce. A tape, or special clamp, or an elastic tourniquet is passed tightly round the root of the penis to control the hæmorrhage during the operation. The prepuce is then pulled *backwards* slightly, till the constricting *ring* is visible, which is then seized by a pair of catch forceps, and *then* the prepuce pulled forwards over the end of the glans; this insures the removal of the tight

Fig. 73.



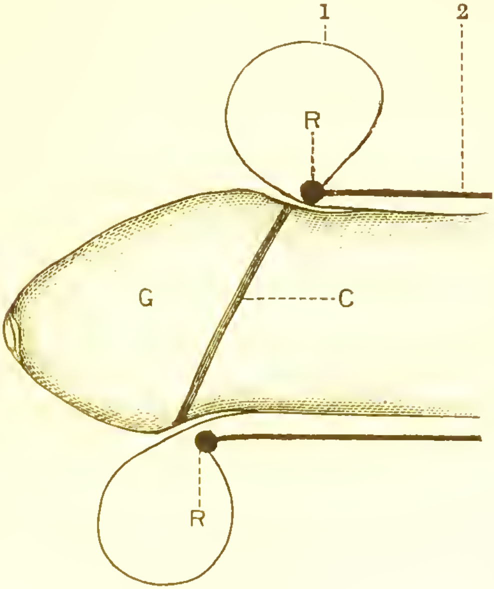
PHIMOSIS.

G. Glans penis. C. Corona glandis. R. R The contracted ring that prevents the prepuce from being pulled back; it is also the point that should be seized by the forceps in circumcision. 1. The cutaneous layer of the prepuce. 2. The 'mucous' layer. 3. 3. Points at which the prepuce should *not* be grasped by the forceps in circumcision.

ring which is the cause of the condition. A pair of long bladed polypus forceps (or dressing forceps) is then placed on the penis at a level with the corona, the blades pointing forwards and downwards; the glans slipping back is thus protected, and the prepuce is sliced off by a sharp scalpel or scissors close to the forceps. Many operators dispense altogether with the use of the forceps as a protective. The mucous layer

still covering the glans is slit up along the dorsum as far as the corona with probe-pointed scissors; it must then be detached from the glans, to which it is often adherent, by means of the finger and thumb, or a probe swept round the organ. The square corners are then to be trimmed off with the scissors, and the mucous and

Fig. 74.



PARAPHIMOSIS.

G. Glans penis. C. Corna glandis. R. R. The contracted ring, which is held behind the corona and keeps up the condition. 1. The collar-like swelling formed by the swollen and œdematous 'mucous' layer of the prepuce. 2. The cutaneous layer of the prepuce.

cutaneous layers stitched together with silk, either by the ordinary interrupted or continuous suture. The patient must rest in bed for a week or ten days. In infants, sutures are unnecessary; all that is required is to wrap a strip of dry lint or iodoform

gauze behind the corona to keep back the mucous membrane.

Paraphimosis.—In this condition the prepuce has been drawn forcibly back, and the ring before mentioned sinks into the sulcus behind the corona glandis and effectually prevents the replacement of the parts into their proper position; the constriction speedily causes great swelling from congestion and œdema forming a large round collar, which is the swollen *mucous* layer of the prepuce, and which is placed in *front* of the constricting ring. In cases requiring an incision the large collar is drawn forwards and the point of a narrow-bladed scalpel passed into the sulcus behind it; it is usually done in the middle of the dorsal surface of the penis, but as the vessels are there it would probably be better to go a little to one side.

Amputation of the Penis.—The chief risk of this operation is the production of an impermeable organic stricture of the urethra at the point of section. To avoid this the corpus spongiosum must be *cut longer* than the corpora cavernosa. Some means must be adopted to control the hæmorrhage, such as the elastic tourniquet, or Clover's clamp; the skin is then divided circularly, and the corpora cavernosa cut carefully through from the dorsal surface, care being taken not to wound the corpus spongiosum, which is then separated from the cavernosa in front and divided three quarters of an inch further forwards. The urethra is then split by a varying number of incisions and stitched to the skin wound; hence as the skin surface contracts it tends rather to dilate the urethral canal. The structures divided are—(1) skin; (2) just under the skin on the dorsum, the central vein with an artery,

and a nerve on each side; (3) the corpora cavernosa with the pectiniform septum, with an artery to each corpus, and one to the septum; (4) the corpus spongiosum. There are therefore five arteries to ligature—the two dorsal arteries, one for each corpus cavernosum, and one in the septum.

CHAPTER XXXIX.

ATTACHMENT OF MUSCLES.

ORIGIN, INSERTION, AND NERVOUS SUPPLY OF THE MORE IMPORTANT MUSCLES MENTIONED IN THE PRECEDING PAGES.

HEAD AND NECK.

1. **Sterno-cleido-mastoid**—*Arises* from the top of the sternum and posterior surface of the inner third of the clavicle, and is *inserted* across the mastoid process of the temporal bone and the outer half of the superior curved line of occipital bone. *Nerves*—Spinal accessory and branches from the cervical plexus.

2. **Sterno-hyoid**—*Arises* from the back of the sternum, first costal cartilage, and clavicle, and is *inserted* into the body of the hyoid bone. *Nerve*—Descendens noni.

3. **Sterno-thyroid**—*Arises* from the back of the first piece of the sternum, and is *inserted* into an oblique line on the side of the thyroid cartilage. *Nerve*—Descendens noni.

4. **Omo-hyoid**—*Arises* from the upper border of the scapula, close to and on the transverse ligament; *inserted* into the body of the hyoid bone. *Nerve*—Descendens noni.

5. **Thyro-hyoid**—*Arises* from the oblique line of the

thyroid cartilage; *inserted* into the body and great cornu of the hyoid bone. *Nerve*—Special branch from ninth (hypoglossal).

6. Masseter—*Arises* from the zygomatic arch and malar bone; *inserted* into the angle and ramus of lower jaw.

7. Temporal—*Arises* from the temporal fossa; *inserted* into the apex and inner surface of the coronoid process.

8. Internal Pterygoid—*Arises* from the pterygoid fossa, especially the inner surface of the external pterygoid plate; *inserted* into the angle and inner surface of ramus.

9. External Pterygoid—*Arises* from the under surface of the great wing of the sphenoid and the outer surface of the external pterygoid plate; *inserted* in front of the neck of the condyle of the lower jaw, and into the inter-articular fibro-cartilage. *Nerves*—The above four muscles are supplied by the third division of the fifth cranial nerve.

10. Digastric—*Arises* from the groove in the mastoid process, perforates the stylo-hyoid, and is attached to the body of the hyoid bone by a central tendon; *inserted* into the under surface of the lower jaw close to the symphysis. *Nerves*—Posterior belly by the facial, anterior by the mylo-hyoid branch of the inferior dental (fifth).

11. Scalenus Anticus—*Arises* from the anterior tubercles of the transverse processes of the third, fourth, fifth, and sixth cervical vertebræ; *inserted* into the tubercle on the inner margin of the first rib, between the grooves for the subclavian artery and vein.

12. Scalenus Medius—*Arises* from the posterior

tubercles of the transverse processes of all the cervical vertebræ except the first; *inserted* into the upper surface of the first rib behind the groove for the subclavian artery.

13. **Scalenus Posticus**—*Arises* from the posterior tubercles of the transverse processes of the lower cervical vertebræ; *inserted* into the outer surface of the second rib. *Nerves*—The scaleni are supplied by supra-clavicular twigs of the brachial plexus.

14. **Trapezius**—*Arises* from the external occipital protuberance, inner third of superior curved line, ligamentum nuchæ, the spinous processes of the last cervical and all the dorsal vertebræ and the supraspinous ligament; *inserted* into the posterior border of the outer third of the clavicle, inner border of acromion, and upper lip of the spine of the scapula. *Nerves*—Spinal accessory and deep branches of the cervical plexus.

15. **Latissimus Dorsi**—*Arises* from the spinous processes of the lower six dorsal vertebræ, posterior layer of the lumbar aponeurosis, and through this to the lumbar and sacral spines, the outer lip of the iliac crest, the last three ribs, interdigitating with the external oblique, and sometimes from the lower angle of the scapula; *inserted* into the bottom of the bicipital groove of the humerus. *Nerve*—The long subscapular.

16. **Levator Anguli Scapulæ**—*Arises* from the posterior tubercles of the transverse processes, of the third, fourth, and fifth cervical vertebræ; *inserted* into the posterior border of the scapula above the spine. *Nerves*—Two or three deep branches of the cervical plexus, and a branch from the nerve to the rhomboids (brachial plexus).

17. **Rhomboideus Minor**—*Arises* from the ligamentum nuchæ and spinous processes of the last cervical and first dorsal vertebræ; *inserted* into the posterior border of the scapula opposite the root of the spine.

18. **Rhomboideus Major**—*Arises* from the spinous processes of the four or five upper dorsal vertebræ; *inserted* into the posterior border of the scapula below the spine. *Nerves*—Both minor and major are supplied by a special supra-clavicular branch of the brachial plexus.

19. **The Superior Constrictor** — *Arises* from the lower third of the internal pterygoid plate, from the hamular process, from the pterygo-maxillary ligament, and from the lower jaw; it is *inserted* into the median raphé behind.

20. **The Middle Constrictor**—*Arises* from the greater and lesser cornua of the hyoid bone, and from the stylo-hyoid ligament; it is *inserted* into the median raphé.

21. **The Inferior Constrictor** — *Arises* from the oblique line of the thyroid cartilage and from the side of the cricoid cartilage; it is *inserted* into the median raphé.

The three constrictors overlap from below upwards, the inferior overlapping the middle, and the middle overlapping the superior. Between the middle and the superior we find (1) the glosso-pharyngeal nerve, (2) the stylo-pharyngeus muscle, and (3) the stylo-hyoid ligament. Between the middle and the inferior we find (1) the superior laryngeal artery, (2) the internal branch of the superior laryngeal nerve, and (3) the external branch of the same nerve. Passing below the inferior we find (1) the recurrent laryngeal nerve, (2) the inferior laryngeal branch of the thyroid artery.

Between the base of the skull and the superior constrictor there is a semi-lunar interval known as the '*space of Morgagni.*' It is filled up by the specially strong submucous coat of the mucous membrane of the pharynx; two muscles are seen in this space—levator palati and the tensor palati, and between them is situated the orifice of the Eustachian tube—and two arteries passing into the pharynx—a branch from the ascending pharyngeal artery, and another from the inferior palatine.

ABDOMEN.

22. **External Oblique**—*Arises* from the outer surfaces of the lower eight ribs by eight digitations; the upper five interdigitate with the serratus magnus, the lower three with the latissimus dorsi; *inserted* into anterior half of the outer lip of the iliac crest, Poupart's ligament, Gimbernat's ligament, triangular fascia, front of pubes, and the whole length of the linea alba.

23. **Internal Oblique**—*Arises* from the outer half of Poupart's ligament, anterior two-thirds of the middle lip of the iliac crest, and from the lumbar aponeurosis: *inserted*, the lower fibres join with the lower fibres of the transversalis to form the conjoined tendon which is inserted into the crest of the pubes and the ilio-pectineal line, also into lower border of the cartilages of the four lower ribs, and the linea alba.

24. **Transversalis**—*Arises* from the outer third of Poupart's ligament, anterior two-thirds of the inner lip of the iliac crest, outer surfaces of the cartilages of the lower six ribs, and by three lamellæ—from the tips of the spinous processes of the lumbar vertebræ, the tips of the transverse processes, and from the bodies of the

vertebræ at the roots of the transverse processes, forming the *fascia lumborum; insertion* into linea alba, pubic crest, and ilio-pectineal line (conjoined tendon).

25. **Quadratus Lumborum**—*Arises* from the ilio-lumbar ligament and iliac crest; *inserted* into the inner half of the last rib and into the tips of the transverse processes of the upper four lumbar vertebræ. *Nerves*—The above four muscles are supplied by the lower six intercostal, the last dorsal, the ilio-hypogastric, and the ilio-inguinal nerves.

26. **Psoas Magnus**—*Arises* from the transverse processes of the lumbar vertebræ, from the intervertebral discs and from the tendinous arches bridging across the four lumbar arteries; *inserted* into the lesser trochanter of the femur. *Nerves*—From lumbar plexus.

27. **Iliacus**—*Arises* from the iliac fossa, ilio-lumbar ligament, base of sacrum, and capsule of the hip joint; *inserted* along with the psoas magnus. *Nerve*—Anterior crural.

UPPER EXTREMITY.

28. **Pectoralis Major**—*Arises* from the anterior surface of the inner half of the clavicle, front of the sternum, cartilages of all the true ribs except first and seventh, and aponeurosis of the external oblique; *inserted* into the outer lip of the bicipital groove. *Nerves*—The external anterior thoracic nerve, and a branch from the internal.

29. **Pectoralis Minor**—*Arises* from the third, fourth, and fifth ribs near their junction with the cartilages; *inserted* into the coracoid process, inner border. *Nerve* internal anterior thoracic.

30. **Serratus Magnus**—*Arises* by nine digitations

from the outer surfaces of the eight upper ribs (the second having two digitations; *inserted* into the anterior surface of the base of the scapula, especially at the upper and lower angles. *Nerve*—The posterior thoracic, or nerve of Bell.

31. **Deltoid** — *Arises* from the outer third of the anterior border of the clavicle, outer border of acromion, and lower edge of spine; *inserted* into the middle of the outer surface of the shaft of the humerus. *Nerve* —Circumflex.

32. **Subscapularis**—*Arises* from the ventral surface of the scapula; *inserted* into the lesser tuberosity of the humerus. *Nerves*—Short and middle subscapulars.

33. **Supra-Spinatus**—*Arises* from the supra-spinous fossa and upper surface of spine; *inserted* into the upper facet or great tuberosity of humerus. *Nerve*— the supra-scapular.

34. **Infraspinatus** — *Arises* from the infraspinous fossa, ridges and fascia; *inserted* into the middle facet on the great tuberosity. *Nerve*—Suprascapular.

35. **Teres Minor**—*Arises* from the upper two-thirds of the dorsal surface of the axillary border of the scapula; *inserted* into the lower facet on great tuberosity. *Nerve*—Branch of circumflex, with ganglion.

36. **Teres Major**—*Arises* from the dorsal surface of the inferior angle of the scapula; *inserted*, inner lip of the bicipital groove of the humerus. *Nerve*—The middle subscapular.

37. **Biceps**—*Arises*, tip of coracoid process and apex of glenoid cavity (long head); *inserted*, back part of the bicipital tubercle of the radius. *Nerve*—Musculo-cutaneous.

38. **Coraco-brachialis.**—*Arises*, tip of coracoid pro-

cess; *inserted*, inner surface of middle of shaft opposite deltoid. *Nerve*—Musculo-cutaneous.

39. **Brachialis Anticus.**—*Arises*, lower half of the inner and outer surfaces of the shaft of the humerus and septa; *inserted*, base of coronoid process of the ulna. *Nerves* — Musculo-cutaneous and musculo-spiral.

40. **Triceps.**—*Arises*, below glenoid fossa of the scapula, posterior surface of the shaft of the humerus, above and below the musculo-spinal groove. *Nerve*—Musculo-spiral.

41. The following **five muscles** all *arise* from the inner condyle of the humerus, septa, and fascia of fore-arm, with *special origins* as follows:—(*a*) **Pronator Radii Teres** — Inner surface of coronoid process; *inserted* into the middle of the outer surface of the shaft of the radius; *Nerve*—The median. (*b*) **Flexor Carpi Radialis**—No *special* origin; *inserted*, front of base of second and partly of the third metacarpal bones; *Nerve*—The median. (*c*) **Palmaris Longus**—No *special* origin; *inserted*, apex of palmar fascia. *Nerve*—The median. (*d*) **Flexor Sublimis Digitorum.**—*Arises*, inner edge of coronoid process of the ulna, above the pronator radii teres, and the oblique line in front of the radius; *inserted*, sides of second phalanges. *Nerve*—The median. (*e*) **Flexor Carpi Ulnaris.**—*Arises*, aponeurosis attached to the posterior edge of the ulna; *inserted*, pisiform bone and fifth metacarpal. *Nerve*—The ulnar.

42. **Flexor Profundus Digitorum.**—*Arises*, upper two-thirds of the anterior and inner surfaces of the shaft of the ulna, aponeurosis attached to the posterior edge of the ulna, and half the interosseous membrane;

inserted, bases of the third phalanges. *Nerves*—Ulnar and anterior interosseous branch of median.

43. **Flexor Longus Pollicis.**—*Arises*, upper part of the anterior surface of the shaft of the radius, interosseous membrane, and sometimes from the inner edge of the coronoid process of the ulna; *inserted*, base of last phalanx of thumb; *Nerve*—Anterior interosseous of median.

44. **Pronator Quadratus.**—*Arises*, lower part of ulna; *inserted*, lower part of radius. *Nerve*—Anterior interosseous from median.

45. **Supinator Longus.**—*Arises*, upper two-thirds of the external condyloid ridge of the humerus; *inserted*, base of styloid process of radius. *Nerve*—Musculo-spiral.

46. **Extensor Carpi Radialis Longior.**—*Arises*, lower third of external condyloid ridge of humerus and septa; *inserted*, back of base of second metacarpal. *Nerve*—The musculo-spiral.

47. **Extensor Carpi Radialis Brevior.**—*Arises*, external condyle, lateral ligament, fascia and septa; *inserted*, back of base of third metacarpal.

48. **Extensor Communis Digitorum.**—*Arises*, external condyle, fascia and septa; *inserted* bases of second and third phalanges of the four fingers.

49. **Extensor Minimi Digiti.**—*Arises*, as last: *inserted*, joins corresponding tendon of the common extensor.

50. **Extensor Carpi Ulnaris.**—*Arises*, external condyle, fascia, and septa, and aponeurosis attached to the posterior border of the ulna; *inserted*, base of metacarpal bone of little finger.

51. **Supinator Brevis.**—*Arises*, common tendon,

orbicular ligament of radius, and depression below lesser sigmoid cavity; *inserted*, posterior and outer surfaces of radius above the oblique line.

52. **Extensor Ossis Metacarpi Pollicis.**—*Arises*, middle thirds of posterior surfaces of both radius and ulna and interosseous membrane; *inserted*, base of first metacarpal bone.

53. **Extensor Primi Internodii Pollicis.**—*Arises*, posterior surface of radius below the previous muscle, and interosseous membrane; *inserted*, base of first phalanx of thumb.

54. **Extensor Secundi Internodii Pollicis.**—*Arises*, posterior surface of the ulna below the ossis and interosseous membrane; *inserted*, base of terminal phalanx of thumb.

55. **Extensor Indicis.**—*Arises*, posterior surface of the ulna below the previous muscle; *inserted*, joins corresponding tendon of common extensor.

The previous *eight* muscles are all supplied by the posterior interosseous division of the musculo-spiral nerve.

LOWER EXTREMITY.

56. **Tensor Fascia Femoris.**—*Arises*, anterior superior spine and crest of ilium behind it; *inserted*, ilio-tibial band. *Nerve*—The superior gluteal.

57. **Sartorius.**—*Arises*, anterior superior spine and notch below; *inserted*, upper part of inner surface of tibia covering gracilis and semi-tendinosus. *Nerve*—Middle or internal cutaneous branch of anterior crural.

58. **Rectus Femoris.**—*Arises*, anterior inferior spine and above brim of acetabulum; *inserted*, upper border of the patella. *Nerve*—Anterior crural.

59. **Vastus Externus.**—*Arises*, anterior border and outer surface of great trochanter, outer border of linea aspera and septa; *inserted*, outer border of patella. *Nerve*—Anterior crural.

60. **Vastus Internus.**—*Arises*, whole length of the side of the linea aspera and septa; *inserted*, inner border of patella. *Nerve*—Anterior crural.

61. **Crureus.**—*Arises*, upper three-fourths of the anterior surface of the femur; *inserted* into upper border of patella. *Nerve*—Anterior crural.

62. **Pectineus.**—*Arises*, ilio-pectineal line and surface in front of it; *inserted* into the line from lesser trochanter to linea aspera. *Nerves*—Obturator and anterior crural.

63. **Gracilis.**—*Arises*, rami of pubes and ischium; *inserted*, upper part of inner surface of the shaft of the tibia above semi-tendinosus and below sartorius. *Nerve*—The obturator.

64. **Adductor Longus.**—*Arises*, by a round tendon just below the crest of the pubes; *inserted*, middle third of inner lip of linea aspera. *Nerve*—The obturator.

65. **Adductor Brevis.**—*Arises*, front of pubes below the longus; *inserted*, linea aspera and line leading from the lesser trochanter. *Nerve*—The obturator.

66. **Adductor Longus.**—*Arises*, outer side of tuberosity of ischium, and rami of ischium and pubes; *inserted*, whole length of the linea aspera crossing obliquely from the outer to the inner side. *Nerves*—Obturator and great sciatic.

67. **Gluteus Maximus.**—*Arises*, superior curved line, crest above this, side of sacrum and coccyx, great sacro-sciatic ligament; *inserted*, ilio-tibial band and line leading from the great trochanter to the linea

aspera. *Nerves*—Inferior gluteal from small sciatic, and special branches from the sacral plexus.

68. **Gluteus Medius.**—*Arises* between superior and middle curved lines and iliac crest; *inserted*, outer surface of great trochanter. *Nerve*—Superior gluteal.

69. **Gluteus Minimus.**—*Arises* between middle and inferior curved lines; *inserted*, anterior border of great trochanter. *Nerve*—Superior gluteal.

70. **Pyriformis.**—*Arises*, front of sacrum between the first, second, third and fourth sacral foramina, edge of great sacro-sciatic foramen and great sacro-sciatic ligament; *inserted*, posterior part of upper border of the great trochanter. *Nerve*—From sacral plexus.

71. **Obturator Internus.**—*Arises*, inner surface of true pelvis round about and over the obturator membrane; *inserted*, joined by the gemelli and inserted into the upper border of the great trochanter. *Nerve*—Special branch from sacral plexus.

72. **Quadratus Femoris.**—*Arises*, outer edge of tuberosity of ischium; *inserted*, linea quadrati on back of great trochanter. *Nerve*—Special branch from sacral plexus.

73. **Obturator Externus.**—*Arises*, outer surface of obturator membrane and bone round; *inserted*, digital fossa of femur. *Nerve*—The obturator.

74. **Biceps.**—*Arises*, lower and inner facet on tuberosity of ischium and outer lip of linea aspera; *inserted*, head of fibula. *Nerve*—Great sciatic.

75. **Semitendinosus.**—*Arises*, with long head of biceps from the tuberosity of the ischium; *inserted*, upper part of inner surface of shaft of tibia below gracilis and beneath the sartorius. *Nerve*—Great sciatic.

76. **Semimembranous.**—*Arises*, upper and outer facet on the tuberosity of the ischium; *inserted*, posterior part of inner tuberosity of the tibia, fascia of popliteus muscle, and posterior ligament of the knee joint. *Nerve*—The great sciatic.

77. **Tibialis Anticus.**—*Arises*, outer tuberosity and upper two-thirds of the shaft of the tibia and interosseous membrane; *inserted*, internal cuneiform and base of first metatarsal. *Nerve*—Anterior tibial.

78. **Extensor Longus Digitorum.**—*Arises*, outer tuberosity of tibia, upper three-fourths of anterior surface of shaft of the fibula, interosseous membrane, and septa; *inserted*, bases of second and third phalanges of the four outer toes. *Nerve*—Anterior tibial.

79. **Extensor Proprius Hallucis.**—*Arises*, middle three-fifths of the anterior surface of the shaft of the fibula internal to the common extensor; *inserted*, base of last phalanx of great toe. *Nerve*—Anterior tibial.

80. **Peroneus Tertius.**—*Arises*, lower fourth of anterior surface of the shaft of the fibula; *inserted*, base of fifth metatarsal. *Nerve*—Anterior tibial.

81. **Peroneus Longus.**—*Arises*, head and upper half of the antero-external surface of the shaft of the fibula; *inserted*, outer side of base of first metatarsal and internal cuneiform bone. *Nerve*—Musculo-cutaneous branch of external popliteal.

82. **Peroneus Brevis.**—*Arises*, middle third of the antero-external surface of the fibula; *inserted*, base of fifth metatarsal. *Nerve*—Musculo-cutaneous.

83. **Gastrocnemius.**—*Arises*, upper and back part of the condyles of the femur; *inserted*, forms part of the tendo Achillis. *Nerve*—Internal popliteal.

84. **Soleus.**—*Arises*, back of head and upper third

of the posterior surface of the fibula, oblique line and inner border of the tibia, and a fibrous arch between the two bones; *inserted*, forms part of the tendo Achillis. *Nerve*—Internal popliteal.

85. **Popliteus.**—*Arises* from a depression on the outer condyle of the femur; *inserted*, triangular surface on the back of the tibia above the oblique line. *Nerve*—Internal popliteal.

86. **Flexor Longus Hallucis.**—*Arises*, lower two-thirds of the posterior surface of the shaft of the fibula; *inserted*, base of last phalanx of great toe. *Nerve*—Posterior tibial.

87. **Flexor Longus Digitorum.**—*Arises*, posterior surface of the shaft of the tibia below the oblique line and internal to the tibialis posticus; *inserted*, bases of the last phalanges of the four outer toes. *Nerve*—Posterior tibial.

88. **Tibialis Posticus.**—*Arises*, posterior surface of the shaft of the tibia below the oblique line and external to the digitorum, interosseous membrane, and upper three-fourths of the inner surface of the shaft of the fibula; *inserted*, tuberosity of scaphoid. *Nerve*—The posterior tibial.

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